Unlocking Flexibility with Law

Diestelmeier, Lea

UNLOCKING FLEXIBILITY WITH LAW

Developing a Legal Framework for Smart Electricity Systems

Lea Diestelmeier

COLOPHON

Layout and cover design:	Design Your Thesis, www.designyourthesis.com
Printing:	Ridderprint B.V., www.ridderprint.nl
ISBN:	978-94-034-1781-3 (printed version)
	978-94-034-1780-6 (electronic version)

rijksuniversiteit
groningen

Unlocking Flexibility with Law

Developing a Legal Framework for Smart Electricity Systems

PhD thesis

to obtain the degree of PhD at the
University of Groningen
on the authority of the
Rector Magnificus prof. E. Sterken
and in accordance with
the decision by the College of Deans.

This thesis will be defended in public on

Thursday 4 July 2019 at 11.00 hours

by

Lea Diestelmeier

born on 17 September 1988
in Langenhagen, Germany

Supervisors
Prof. H.H.B. Vedder
Prof. M.M. Roggenkamp

Assessment Committee
Prof. G.P. Mifsud Bonnici
Prof. M. Mulder
Prof. J.B. Eisen

Paranymphs
Dirk Kuiken
Tatiana Spijk-Belanova

Für meine Eltern, Immy Steenwijk & Heinrich Diestelmeier
und meine Schwestern, Lisa & Johanna

ACKNOWLEDGMENTS

In pursuing this PhD, I feel very fortunate that I could rely on the support of my supervisors, colleagues, family, and friends.

First and foremost, I would like to thank my supervisors for their continuous guidance.

Hans, in a most natural way you constructively helped me to reflect and progress. Your talent to teach is complemented by your positive and unconstrained character. I feel privileged that I could enjoy your mentorship. You equipped me to continue learning way beyond the boundaries of a PhD. Thank you.

Martha, you introduced me to the field of energy law in 2012 when I started as a master student. Thank you for all the opportunities that you have provided me since then. Your expertise and network in the field of energy law opened a new world for me.

This research would not have been possible without the Netherlands Organisation for Scientific Research (NWO) initiating and financing the research project URSES (*Uncertainty Reduction in Smart Energy Systems*) and SmaRds (*Smart Regimes for Smart Grids*). Special thanks also to the project team of SmaRds, Dr. Maarten Arentsen, Prof. Michiel Heldeweg, Dr. Thomas Hoppe, and of course Dr. Imke Lammers and the members of the user committee.

My gratitude to the assessment committee, composed of Prof. Jeanne Mifsud Bonnici, Prof. Machiel Mulder, and Prof. Joel Eisen. Thank you for reading my manuscript. Your comments are highly appreciated and will certainly enhance my further work.

My paranymphs deserve a special thanks: Tatiana, your enthusiastic and truly caring nature has been invaluable during the past years. Dirk, our journey through the jungle of smart grids would not have been the same without your sense of humour and craving for coffee.

I had the pleasure to work with a bunch of different and unique people at the faculty of law and in particular at the Groningen Centre of Energy Law & Sustainability. All of you have contributed to a lively work surrounding.

I would like to thank the Graduate School and especially Prof. Pauline Westerman, Anita Kram, and Marjolijn Both for their continuous support, in particular with the "last sprint".

Beyond the university, I am deeply grateful to my family. My parents, Immy and Heinrich. You enabled me to become who I am and to trust myself to always find my way. My sisters, Lisa and Johanna. Both of you enrich my life by allowing me to look beyond my own horizon. Stephan, the memories we share are priceless. I am certain that as we continue our lives in different pathways, our time will remain a part of us.

A great extent of joy and support in my life comes from friendship. My sincere thanks goes out to all of you.

Thank you, Marc. Your ability to balance between simply being at ease and yet critically reflecting makes it joyful and inspiring being around you. Sharing life with you multiplies happiness. *Que suerte!*

Lea Diestelmeier

May 2019

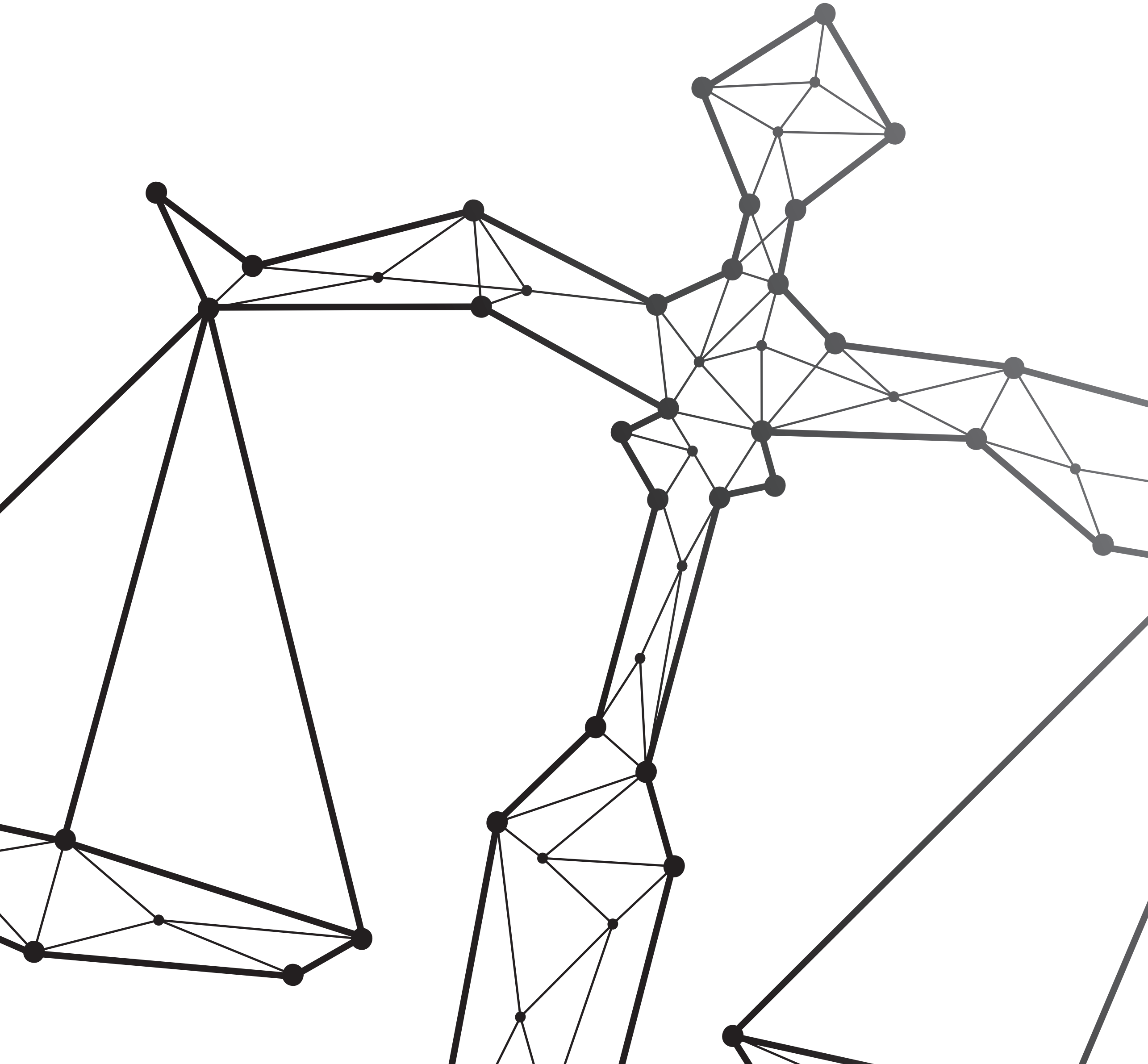
OVERVIEW OF CONTENTS

CONTENTS

ABBREVIATIONS

ACER	Agency for the Cooperation of Energy Regulators
AC	Alternating Current
AEG	Allgemeine Elektricitäts-Gesellschaft
CCS	Carbon Capture and Storage
CEC	Citizen Energy Community
CEP	Clean Energy Package for All Europeans
CO2	Carbon Dioxide
DC	Direct Current
DDE	Decentrale Duurzame Elektriciteitsopwekking
DG	Decentral Generation
DSL	Digital Subscriber Lines
DSM	Demand Side Management
DSO	Distribution System Operator
DSR	Demand Side Response
EC	European Communities
ECSC	European Coal and Steel Community
ECJ	European Court of Justice
ECR	European Court Report
EEA	European Environment Agency
ENTSO-E	European Network for Transmission System Operators for Electricity
EU	European Union
ETS	Emission Trading Scheme
FiT	Feed-in-Tariff
FULDA	Function-based Legal Design & Analysis
GHG	Green House Gas
ICT	Information and Communication Technologies
IEA	International Energy Agency
IEM	Internal Energy Market
IPCC	Intergovernmental Panel on Climate Change
ISO	Independent System Operator

ITO	Independent Transmission Operator
kW	kilo Watt
kWh	kilo Watt hours
LEC	Local Energy Community
MEA	Ministry of Economic Affairs
NRA	National Regulatory Authorities
NREAP	National Renewable Energy Action Plan
NTYNDP	National Ten-Year Network Development Plan
PLC	Power Line Communications
P2P	Peer-to-Peer
QoS	Quality of Service
RED	Renewable Energy Directive
RES	Renewable Energy Sources
RSC	Renewable Self-Consumer
RTP	Real-time Pricing
RWE	Rheinisch-Westfälische Elektrizitätswerk Aktiengesellschaft
SAIFI	System Average Interruption Frequency Index
SAIDI	System Average Interruption Duration Index
SES	Smart Electricity System
SHT	Smart Home Technologies
SmaRds	Smart Regimes for Smart Grids
SME	Small- and Medium-sized Enterprises
TPA	Third Party Access
TFEU	Treaty on the Functioning of the European Union
TSO	Transmission System Operator
UCPTE	Union for the Coordination of Production and Transmission of Electricity
UNFCCC	United Nations secretariat for the Framework Convention on Climate Change
URSES	Uncertainty Reduction in Smart Energy Systems
WLAN	Wireless Local Area Network
WPAN	Wireless Personal Area Network



INTRODUCTION:
UNLOCKING FLEXIBILITY WITH LAW

1. INTRODUCTION

The uptake of renewable energy sources (RES) in the energy sector is high on the agenda of the European Commission as a key measure to mitigate climate change and to reduce fuel dependency from third countries.[1] This further materialised in the legal obligation for EU member states to reach a specific target of RES in gross final consumption and the possibility to develop support schemes incentivising the production of energy on the basis of RES on the national level.[2] In the electricity sector, this led to the deployment of various scales of RES generation technologies connected to the high-voltage transmission system, but also to the low-voltage distribution system.[3] While RES have the main advantage of not releasing carbon emissions during electricity generation, the integration of RES in the existing electricity system presents other challenges. These challenges are inherent to the very nature of RES that is variability or also referred to as intermittency.[4] Variability entails on the one hand sudden increases in generation requiring grid capacities being capable of capturing peaks, and on the other hand it also entails generation dips which need to be balanced with other, conventional (meaning fossil or nuclear), available energy sources.[5] While these challenges can be overcome, or at least be mitigated, solutions come at a cost.[6] Generally, solutions can be categorised in two different approaches. One approach is based on expanding the grid

1. Since the adoption of the policy in 1997 to increase the overall share of RES (including heating, electricity generation, and transport) within the EU with 12% by 2010, the support of RES is continuously included in EU policy documents and further complemented in legislation. The development of this policy and legislation is further outlined in chapter 1, section 3.2 “Climate Change Mitigation”. The policy document of 1997 refers to the following: Commission of the EC, ‘Energy for the Future: Renewable Sources of Energy. White Paper for a Community Strategy and Action Plan’ COM(97)599 final.
2. Mandatory national overall targets and measures for the use of energy from renewable sources are prescribed by article 3 in conjunction with part A of Annex I Directive (EC) No 2009/28 on the Promotion of the Use of Energy from Renewable Sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC [2009] OJ L140/16. In the following Directive 2009/28/EC. The most common incentivising measure for RES are support schemes, which allow member states to provide financial support to electricity produced on basis of RES. Support schemes are broadly defined in article 2(k) of that Directive. At the time of finalising this thesis, Directive 2009/28/EC was amended. Instead of individual national targets, the amended Directive 2018/2001/EU now includes an overall EU target for RES. This is discussed in chapter 1, section 3.2.4 “The Way Forward: Including Decentralisation in EU RES Legislation”.
3. The electricity system entails two operational levels, the high-voltage transmission system which transports the electricity from large remote generation over longer distances to transformer stations where the voltage level is reduced and from where the electricity is forwarded by the low-voltage distribution systems to the loads, the points of final consumption. This setting is further explained in chapter 1 of this thesis. Regarding RES connected to the electricity system, capacity is growing. The European Environment Agency (EEA) reports that *“In 2017, 85 % of all newly installed power capacity in the EU was of renewable origin, with wind power and solar PV accounting for three quarters of the annual increase in renewable power capacity”*. EEA report, ‘Renewable Energy in Europe — 2018 – Recent Growth and Knock-on Effects’ No 20/2018, 6.
4. Joan Batalla-Bejerano and Elisa Trujillo-Baute, ‘Impacts of Intermittent Renewable Generation on Electricity System Costs’ (2016) 94 Energy Policy 411-420, 412.
5. Marek Kubik, Phil Coker, and C. Hunt, ‘The Role of Conventional Generation in Managing Variability’ (2012) 50 Energy Policy 253-260, 254.
6. Bruce Stram, ‘Key Challenges to Expanding Renewable Energy’ (2016) 96 Energy Policy 728-734, 730.

infrastructure and adding spinning generation reserves.[7] Reinforced grid infrastructure would capture generation peaks and spinning generation reserves would need to be constantly available, thus based on controllable conventional energy sources, to balance output dips of RES. On the contrary, another approach aims at integrating flexibilities of consumers for better matching the variable generation of RES with electricity demand.[8] In the latter approach the costs of variability would thus not be exacerbated by expanding grid capacities and balancing generation reserves, but would be internalised by allocating costs to the system users (producer or consumer) inducing them. Likewise, benefits for mitigating variability costs would be allocated individually. This would ideally lead to a system which accurately reflects the variability of resources in variable, usually referred to as dynamic, prices. Dynamic prices could function as a financial incentive for consumers to adjust their demand. Demand flexibility thus becomes of essential value with an increasing amount of RES. In the current EU electricity sector, the possibility to offer demand flexibility depending on dynamic prices is mostly directed towards large consumers, for example industries with high electricity consumption.[9] Flexibilities of small consumers located at the distribution grid level remain largely idle.[10] Unlocking these potential flexibilities requires electricity systems that enable, incentivise, and coordinate efficiency gains also at distribution grid level. Such systems are often referred to as "smart grids" or as "smart electricity systems" and are subject to this thesis.[11]

At this point, it is relevant to clarify the terminology. The term "smart grid" is most commonly used in existing reports and literature. Yet, research reveals that the specific meaning of this term is often uncertain or at least varies to a great extent.[12] Furthermore, the term smart grid suggests that it is the grid which becomes "smart". The focus of this thesis, however, extends beyond the grid infrastructure and the key findings of this thesis even suggest that only the interplay and coordination of different technical components and actors in the electricity system will enable a "smart electricity system". Hereafter, this thesis will thus apply the term "smart electricity system" (SES) and refers

7. The term "spinning generation reserve" refers to generation which is primarily available for covering possible generation dips, such as off-peak generation of RES. It can generally be defined as follows: *"The spinning reserve is the unused capacity which can be activated on decision of the system operator and which is provided by devices which are synchronized to the network and able to affect the active power."* Yann Rebours and Daniel Kirschen, 'What is Spinning Reserve?' University of Manchester (19 September 2005), 7.
8. Goran Strbac, 'Demand Side Management: Benefits and Challenges' 2008 36(12) Energy Policy 4419-4426, 4422.
9. Commission of the EU, Joint Research Centre, 'Demand Response Status in EU Member States' (2016) 127.
10. Hans Gils, 'Assessment of Theoretical Demand Response Potential in Europe' (2014) 67 Energy 1-18, 6.
11. Cédric Clastres, 'Smart Grids: Another Step towards Competition, Energy Security and Climate Change Objectives' (2011) 39 Energy Policy 5399-5408, 5400.
12. Anne Beaulieu, 'What are Smart Grids? Epistemology, Interdisciplinarity and Getting Things Done' in Anne Beaulieu, Jaap de Wilde, and Jaquelien Scherpen (eds) *Smart Grids from a Global Perspective: Bridging Old and New Energy Systems* (Springer 2016) 63-73.

to the distribution system level. The term is applied in so far interchangeably with "smart grid" as reports and literature which apply the term "smart grid" are certainly also used as sources for this research.

SES are considered promising for reconciling the overarching EU policy objectives of the electricity sector that are ensuring a *secure*, *competitive*, and *sustainable* electricity supply.[13] Therefore, SES are envisaged as one of the centre pieces of the energy transition by policymakers in the EU.[14] The EU Commission also incorporated many SES related aspects in its legislative proposal entitled *"Clean Energy for All Europeans"* published in November 2016 which is currently in the legislative process and already partly adopted.[15] The preceding paragraph introduced SES as a capacity-efficient solution for integrating RES in the electricity system. While this suggests that SES are largely driven by technology and economic efficiency objectives, SES also have implications for the legal framework of the electricity sector. *Vice versa*, and this is core to this thesis, making SES viable even requires the legal framework to be geared towards the functionalities of SES. Generally, the legal framework of the electricity sector establishes roles and responsibilities for the users of the network, who are referred to as system users (producers and consumers), the system operators for different voltage levels (transmission and distribution systems), and coordinating and supervising bodies at national and supranational level. Currently, SES are not yet existent beyond pilot project scales and reports often mention the legal framework as one of the obstacles for the further development of SES.[16] Therefore, this thesis aims at exploring which legal framework enables and incentivises SES.

Exploring a legal framework for SES firstly requires identifying how SES differ from the current electricity system. This thesis assumes that the core of SES requires two major adjustments to the current technical electricity system and the market setting of the

13. Those three main objectives continuously emerged and developed in EU policy documents and subsequent legislation which is further outlined this thesis. Chapter 2 of this thesis specifically addresses these policy goals. The EU Commission reiterated those objectives in various documents in the last decades. For example, Commission of the EU, Communication on Energy Roadmap 2050, COM(2011)885 final, 15.12.2011, 2; Commission of the EU, Communication on Energy 2020: A Strategy for Competitive, Sustainable, and Secure Energy, COM(2010) 639 final, 10.11.2010, 2; Commission of the EC, Communication on an Energy Policy for Europe, COM(2007) 1 final, 10.1.2007, 3-4; Commission of the EC, Green Paper on a European Strategy for Sustainable, Competitive and Secure Energy, COM(2006) 105 final, 8.3.2006, 3. Furthermore these objectives are also enshrined in primary EU law in article 194 of the Treaty on the Functioning of the European Union (TFEU) which establishes that the EU energy policy aims shall aim at the functioning of the internal energy market, ensuring security of energy supply, promoting energy efficiency and RES, and interconnection of energy networks.
14. The EU Commission set up a "Smart Grid Task Force" which is assigned the task to investigate policy and regulatory frameworks at European level for smart grids and has an advisory function to the EU Commission. Furthermore, the Joint Research Centre of the EU observes smart grid initiatives across EU countries and publishes their findings in "Smart Grid Outlooks". The most recent report was published in 2017, Commission of the EU, Joint Research Centre 'Smart Grid Projects Outlook 2017 – Facts Figures and Trends in Europe' (Publications Office of the European Union, 2017).
15. EU Commission, 'Clean Energy Package for All Europeans - Commission proposes New Rules for Consumer Centred Clean Energy Transition' (30 November 2016). This proposal is discussed mainly in chapter 4 of this thesis.
16. Commission of the EU, Joint Research Centre, Smart Grid Projects Outlook (2011, 2012, 2014, 2017).

electricity sector. A sophisticated technical setting by adding communication networks and smart metering systems, and a modified economic setting by integrating demand-side flexibilities located at the distribution system level in the market. Secondly, these findings require analysing implications for the legal framework of the electricity sector. SES functionalities amplify the abilities and roles of system users and system operators. These changing abilities and roles need to be further identified and subsequently incorporated in the legal framework of the electricity sector in order to enable and incentivise SES. Both steps, identifying SES functionalities and consequences for the legal framework enabling an incentivising SES, are undertaken in this thesis. The following sections explain this research and more specifically the setting of this thesis in greater detail.

2. RESEARCH

This thesis is carried out under the Netherlands Organisation for Scientific Research (NWO) umbrella project *"Uncertainty Reduction in Smart Energy Systems"* (URSES)[17] and is part of the research project "SmaRds" (*"Smart Regimes for Smart Grids"*) which is undertaken jointly with the University of Twente. "Uncertainty reduction" refers to the need to clarify the understanding of smart energy systems from the perspective of various disciplines ranging from engineering, computer science, economics, social and behavioural sciences, law, and public administration. The research project "SmaRds" specifically addresses the intertwined uncertainties of the legal design of emerging organisational settings in SES configurations (legal part of project, present thesis) and the policy design of SES implementation trajectories in municipalities (public administration part of project, University of Twente).[18]

As mentioned in the introduction, SES are driven by technology and economic efficiency objectives. In this view, this thesis cannot be undertaken as a purely legal research, but needs to be carried out at the cross-roads of various disciplines, more specifically, technology, economics and public administration. To this end, this thesis applies what is here referred to as "system component approach" and assumes a reciprocal relation between technology and organisation. More specifically, the organisational component is composed of law and economics.[19] Certainly, underlying law are policy objectives which materialise in legislation. However, the focus of this thesis is the development of a

17. Netherlands Organisation for Scientific Research, URSES.
18. Imke Lammers, *Rules for Watt? Designing Appropriate Governance Arrangements for the Introduction of Smart Grids*, (Dissertation University of Twente 2018).
19. Hamilcar Knops, *A Functional Legal Design for Reliable Electricity Supply – How Technology Affects Law* (Energy & Law Series 6 Intersentia 2008).

legal framework which enables and incentivises SES. The policy objectives which led the way towards this development are not considered in the system component approach, but are outlined in chapter 2 of this thesis. The approach and its scientific background are further explained below in section 2.5 on the methodology of this thesis. For now, it is relevant to mention that this thesis assumes two main interrelated components of the electricity sector, namely technology and organisation. The following sections outline the relevance, aim and scope, the research questions, and the methodology and approach of this thesis in greater detail.

2.1 Relevance

Gradually replacing carbon dioxide (CO_2) emission releasing energy sources with RES is essential for mitigating climate change. Reaping the major advantage of emission-free RES however requires more than changing the sources of electricity generation from fossil- to renewable energy sources. Equally important is harnessing the electricity generated by RES efficiently.[20] SES offer a way to do so by including the demand side, in particular demand connected to the distribution system, as a flexible part in the supply chain. From a technical perspective this implies upgrading the electricity system with ICT infrastructure and communicating system capabilities among all system users. From an economic perspective this implies to also include system users connected to the distribution grid level as flexibility providers, such as for example residential customers. This thesis aims at exploring the legal implications of SES. The relevance of this research is thus given by the following two intertwined dimensions: Firstly, by the overarching dimension to mitigate climate change by means of replacing emission-releasing energy sources with RES. Secondly, by the need to identify which legal framework enables and incentivises SES. While the first point of relevance is only indirectly subject to this thesis (the relevance of increasing RES for mitigating climate change is not analysed in this thesis), the second point is of direct relevance and therefore requires some further elaboration.

The current legal framework was not designed for SES at distribution system level, as it is tailored to a largely centrally organised sector. In this thesis, centrally organised sector refers to an electricity sector with large remote generation mainly based on conventional controllable sources (fossil or nuclear), high-voltage transmission systems serving as "backbones", low-voltage distribution systems as "appendages" passing on electricity to the point of final consumption. However, with the increase of variable supply connected to the distribution grid, this setting needs to change. The legal framework of the sector defines actors and subsequent rights and responsibilities along

20. Henrik Lund, 'Renewable Energy Strategies for Sustainable Development' (2007) 32 Energy 912-919, 917.

this "top-down" electricity supply-chain. These actors are producers, transmission- and distribution system operators, suppliers, and consumers. This setting stands in contrast to the envisaged SES which aim at incentivising and coordinating the demand-side as a flexible part of the electricity supply chain. In addition to the current electricity system, the technical setting of SES includes ICT infrastructure and the economic setting includes flexibilities of system users (producers and consumers). This requires identifying new roles and responsibilities related to the operation of ICT infrastructures in SES and also of system users at distribution grid level as flexibility providers. Both aspects are central to SES and not yet considered in the current legal framework. This thesis aims at contributing to close this knowledge gap by exploring and developing a legal framework which enables and incentivises SES at distribution system level. The following section introduces the more specific aim and scope of this thesis.

2.2 Aim and Scope

This thesis primarily aims at improving the knowledge on implications for a legal framework which enables and incentivises SES with a focus on the role of actors in the sector. While the NWO umbrella project URSES mentions "smart *energy* systems", this thesis exclusively addresses the electricity sector. More specifically, the scope of this thesis entails the EU electricity sector and therefore mainly refers to EU legislation when mentioning the "legal framework", more specifically, legislation which governs the establishment of the internal electricity market and defines the roles and responsibilities of actors in the sector. This section outlines the aim and the reasons for the choices of the scope in more detail.

Generally, understanding technical innovations from a legal perspective requires going beyond mere legal science.[21] This thesis aims at undertaking this endeavour for the technical innovation of SES. As briefly mentioned in the introduction, one of the most common obstacles mentioned for the deployment of SES is a lacking general understanding of what SES are or what they are anticipated to be.[22] While this thesis acknowledges this claim, it does not aim at asserting a general and complete definition of SES. On the contrary, this thesis aims at showing that there can be no single definition, but rather a range of understanding of elements which can be included in SES and which are necessary for a defined goal. In that sense, the defined goal becomes of greater relevance than the specific technology deployed. This claim constitutes the main theoretical basis for this thesis aiming to develop a legal framework for SES.

21. Michiel Heldeweg and Evisa Kica (eds) *Regulating Technological Innovation – A Multidisciplinary Approach* (Palgrave 2011).
22. Anne Beaulieu, 'What are Smart Grids? Epistemology, Interdisciplinarity and Getting Things Done' in Anne Beaulieu, Jaap de Wilde, and Jaquelien Scherpen (eds), *Smart Grids from a Global Perspective: Bridging Old and New Energy Systems* (Springer 2016) 63-73.

Leading to the main purpose (that is improving the knowledge on implications for a legal framework which enables and incentivises SES), this thesis entails the following consecutive steps which are each elaborated in dedicated chapters:

1. Introducing the "system component approach" for understanding the relation between technology and law in the context of the electricity sector. Specifically, the aim is to identify the role of law in the development of the electricity sector (chapter 1).
2. Describing the main objectives behind SES and identifying their conflict with the current technical setting of the electricity system and the legal framework of the electricity sector (chapter 2).
3. Identifying the main technical functionalities of SES and establishing theoretical groundwork for the development of a legal framework for those functionalities (chapter 3).
4. Identifying and analysing main elements of a legal framework which enables and incentivises SES on basis of SES functionalities (chapter 4).

In line with the approach to distinguish between the technology component and the organisation component of the system, the scope of this thesis entails the following two dimensions: the technical dimension is set by focusing on the distribution system level and the law dimension is set by focusing on the EU electricity sector legislation. The reason for the choice to focus on the distribution grid level is provided by the technical developments of SES which are mainly directed to- and tailored for the distribution grid level. At distribution grid level, the urgency for finding new grid operation approaches is caused by increasing amounts of small-scale generation on the basis of RES and growing demand.[23] This requires a much more accurate way of distribution grid operation than in the current "top-down" setting, where the distribution grid mainly passively forwards the electricity flows from higher-voltage system parts to the consumers. The reason to focus on EU legislation is motivated by the overall aim to establish an internal electricity market in the EU and the recent legislative proposal of the EU Commission to reform the electricity sector which foresees furthering the decentralisation of the electricity sector.[24] This thesis works on the assumption that EU law will become increasingly relevant for establishing these objectives.

23. Danny Pudjianto, Predrag Djapic, Marko Aunedi, Chin Kim Gan, Goran Strbac, Sikai Huang, and David Infield, 'Smart Control for Minimizing Distribution Network Reinforcement Cost due to Electrification' (2013) 52 Energy Policy 76-84, 82.
24. The goal and legal measures to establish and internal energy market are explained in chapter 1 of this thesis. The recent legislative proposal to reform the electricity sector was published by the EU Commission in November 2016 and is often referred to as "Winter Package". Officially, the legislative proposal is referred to as EU Commission, 'Clean Energy Package for All Europeans' (30 November 2016). The proposal and its relevance for this thesis are discussed in chapter 4 of this thesis.

2.3 Research Questions

To accomplish the main aim of this thesis, which is improving the knowledge on implications for a legal framework which enables and incentivises SES, this thesis combines descriptive, analytical, and explorative research. These different research approaches are reflected in the research questions guiding this thesis.

Chapter 1 is mainly descriptive and entails an outline of the development of the electricity sector and the role of law in this development. Additionally, the chapter includes an analytical level which investigates the relation between technology and law in the electricity sector. The chapter answers the following research question:

- *What is the role of law in the development of the electricity sector?*

Similarly, chapter 2 combines descriptive and analytical research by identifying the main objectives behind SES and analysing legal constraints in the development of a legal framework for innovation in the electricity sector (SES). The chapter answers the following research question:

- *What is the rationale behind the idea of SES and what are constraints in developing a legal framework for SES?*

Chapter 3 entails a descriptive element which outlines the main technical functionalities of SES, an analytical element by drawing analogies from the telecommunications sector for developing a legal framework as a response to technical innovation in a network industry, and an explorative element which introduces technology-neutral- and goal-oriented law as technique for developing a legal framework for SES. The chapter answers the following research question:

- *Which theoretical framework supports the development of a legal framework for SES?*

Chapter 4 is mainly of explorative nature by developing the main legal elements of a legal framework which incentivises SES. The chapter does so by relating the technical functionalities of SES which were identified in chapter 3 to the changing role of system users, the system, and interactions. The chapter answers the following research question:

- *What are main elements of a legal framework which enables and incentivises SES?*

The conclusion of the thesis compiles the main findings of the chapters and answers the following main research question

- *Which legal framework enables and incentivises SES?*

The thesis thus departs from the current setting, via objectives, to functionalities, and eventually a legal framework for SES. Inherent to all parts is the relation between technology and law aiming at developing a legal framework which reflects the functionalities of a changing technical system. The following section elaborates further on how this is accomplished.

2.4 Methodology and Approach

Inherent to all parts of this thesis is the relation among technology, economics, and law which is referred to as "system component approach" including the two main components technology and organisation. This approach builds upon existing research which established the "function-based legal design & analysis" method (FULDA method).[25] Essentially, this method departs from the identification of the necessary technical functions of the electricity system and provides a decisions-making tool for the legal organisation of specific functions. The research establishing the FULDA-method was completed in 2007 and carried out in the middle of the liberalisation process of the energy sector in the EU. The political choice to restructure the energy sector from public utilities to a common liberalised market required legally re-organising the sector. Against this background, the FULDA-method provided a systematic approach for the development of a legal framework for the restructuring and integration process of the electricity sector in the EU.[26] However, the method also provides a more general tool beyond the reorganisation during the liberalisation process as the conceptual framework allows systematically identifying technical functionalities of the electricity system and analysing resulting questions for the legal organisation of these functions. Therefore, even though this thesis is not driven by an institutional restructuring process of the electricity sector, but by the technical development of SES, the FULDA method provides a valuable approach for categorising the electricity system into two main components, namely technology and organisation. The organisational component is further composed of economics and law. As briefly mentioned, policy is certainly also a driving component in the system, as policy objectives can change and thereby steer technical developments and initiate new legislation. However, the policy dimension is

25. Hamilcar Knops, A Functional Legal Design for Reliable Electricity Supply – How Technology Affects Law (Energy & Law Series 6 Intersentia 2008), 163.
26. Hamilcar Knops, A Functional Legal Design for Reliable Electricity Supply – How Technology Affects Law (Energy & Law Series 6 Intersentia 2008), 18.

not the focus of this thesis, as the aim is to develop a legal framework which enables an incentivises SES. The policy objectives underlying the emergence of SES are outlined in chapter 2 of this thesis. This will then lead to the quest for new legislation which is the topic of this thesis.

As a result of applying the "system component approach" this thesis relies to a great extent on the analysis of secondary sources for the technology, organisational and economic aspects of SES. Understanding the main technical and economic implications of SES will form the basis for the development of the legal framework implementing a functional approach to the law. This thesis identifies the interests of- and the regulatory framework applicable to the parties involved, including existing parties (such as system operators, producers, suppliers, and consumers) and potential new parties and roles (such as aggregators, communication network operators, and system users at distribution grid level as flexibility providers). However, as these new parties are not existent yet, this thesis can only assume potential new actors from the technical functionalities of SES. Concerning their position in the electricity sector, the working assumption will be that in a liberalised framework, monopolistic activities should be minimised and barriers to entry to the market should be as low as possible. This working assumption follows from the current legal framework, but may need to be refined in the light of the technical and economic characteristics of SES. This feedback-relation between the assumptions underlying the current legal framework and the characteristics of SES is the essential complexity that is identified and analysed in this thesis.

Against the backdrop of the above outlined approach and the inference to include secondary sources from technology and economic disciplines requires the need to extend beyond doctrinal legal research as a methodology. Doctrinal legal research describes research which *"asks what the law is in a particular area"*.[27] The aim is thus mainly descriptive which is also reflected in its methodology by consulting existing or historic legislation. While this thesis certainly also considers existing and historic legislation, a purely doctrinal approach would be too limited as the main objective of this thesis is of explorative nature given by the primary research aim to develop a legal framework which enables and incentivises SES.

27. Ian Dobinson and Francis Johns, 'Legal Research as Qualitative Research' in Mike McConville and Wing Hong Chui (eds) *Research Methods for Law* (Edinburgh University Press 2017) 18-47, 21.

3. STRUCTURE

This thesis aims at developing a legal framework closely connected to the technical functionalities of SES in a technology-neutral and goal-oriented fashion. Following this introduction, this thesis materialises in four chapters plus a conclusion.

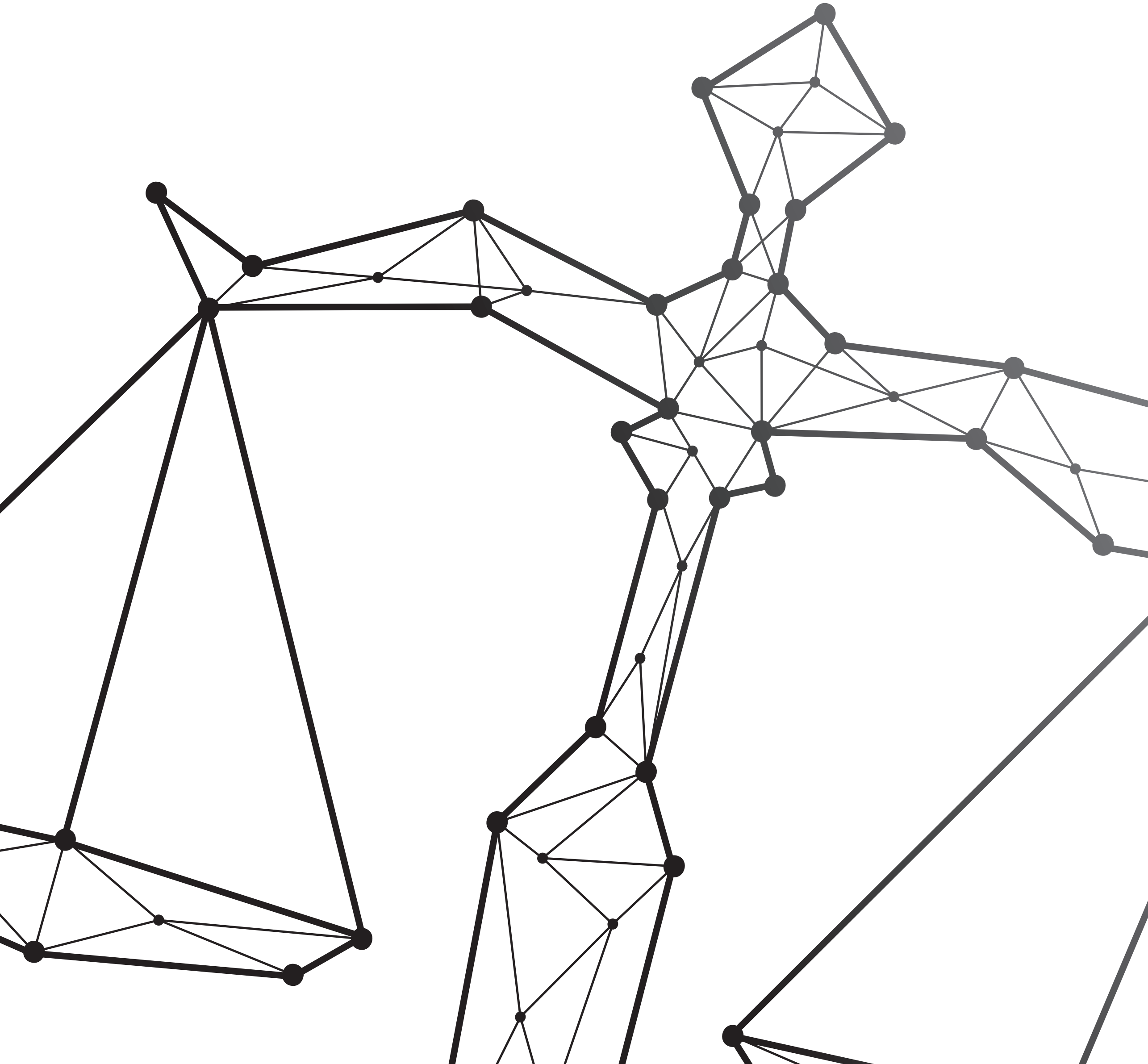
Chapter 1 identifies and describes the role of law in the development of the electricity sector. The thesis thereby starts with determining the legislative framework and its development of the EU electricity sector on the basis of historic- and existing legislation. The chapter introduces and establishes the approach applied throughout this research which distinguishes between the technology component and the organisational component in the electricity sector. The chapter concludes that the relationship of the components is reciprocal.

Chapter 2 applies the system component approach by relating the technical component of the electricity system to the main EU policy goals (organisational component) for the electricity sector. The chapter outlines SES along their main objectives and subsequently identifies the need for a novel legal framework. The chapter concludes that existing approaches in developing a legal framework for SES remain insufficient and mainly result in incremental knowledge generation.

Chapter 3 develops theoretical groundwork for the development of a legal framework for SES. The chapter operationalises the SES objectives outlined in chapter 2, by identifying main SES functionalities, which are flexibility, communication networks, and data. The chapter argues that SES are multifaceted systems which require a legal framework which is based on the main technical functionalities of SES, thus a technology-neutral, goal-oriented legal framework.

Chapter 4 develops a legal framework based on SES functionalities (flexibility, communication networks, and data) by identifying the main consequences for the role of system users, the electricity system, and interactions within SES. The chapter bridges findings of this research to the legislative proposal of the European Commission to reform the electricity sector (*Clean Energy for All Europeans*) published in November 2016.

The conclusion answers the research questions and draws initial policy inferences for a legal framework which incentivises SES. Inevitably, these policy inferences lead to the quest for further research advancing the development of a legal framework which incentivises SES in greater detail.



CHAPTER 1:
THE ROLE OF LAW IN THE DEVELOPMENT OF THE ELECTRICITY SECTOR

1. INTRODUCTION

This chapter describes the development of the electricity sector and analyses the role of law therein. The chapter hypothesises that the development of the electricity sector is a continuous and reciprocal relation between technology and organisation, which is composed of economics and law. To understand this relation this chapter comprises the following three steps: firstly, describing the electricity sector setting, secondly, identifying the role of law therein, and thirdly, detecting emerging developments in the electricity sector and relating those to legal challenges. This approach not only allows understanding the role of law in the development of the electricity sector, but it also enables examining recent and ongoing developments in the sector. In that sense, the overall aim of this chapter is not only to sketch the current setting of the electricity sector, but also to establish a methodology on how to apply legal research in relation to technical innovation in the electricity sector, more specifically, the emergence of SES.

To avoid confusion, it is relevant to distinguish the terms "electricity system" and "electricity sector" for the purpose of this thesis. This chapter applies the term "electricity system" to refer to the physical system, that is the electricity grid (also referred to as network), generation installations (also referred to as production), and loads (also referred to as consumption). The term "electricity sector" refers to the industry which includes all activities ranging from generation to grid operation, to consumption, and the respective actors and stakeholders. Both, the system and the sector are connected. On the one hand, the highly technical character of the electricity system lays down requirements for the organisation of the sector; on the other hand the organisation of the sector determines how the system is used. This chapter analyses the role of law in the development of the electricity sector and structures the analysis along two main components of the electricity sector; the technical system and the organisational setting, whereas the latter one comprises economics and law for the purpose of this thesis.

The components differ in their characteristics and partly influence each other. Technology is at the core because the physical features of electricity are predetermined. The organisation of the sector is partly determined by the technology and shaped by the legal framework. The legal framework shapes the economic setting by assigning rights and responsibilities to various actors and potentially incentivises or hinders technological development. Analysing current challenges in the development of the electricity system and subsequently identifying legal questions also requires understanding the underlying dynamics of the components. The components and the extent of their interaction have been changing with the technical development of the electricity system and with the subsequent extension of actors, from local, to national, to regional levels.

> *"In a grand view on electrical history it is possible to distinguish between three eras in the development of electricity supply systems on a national level* [1880-1920: introducing electricity, 1920-1970 scale increase and expansion, 1970-2000 hybrid systems – characterised by economic liberalisation and environmental values]. *Each era was characterized by (interrelated) elements such as leading concerns or critical problems, dominant actor groups who formulated these problems and who, put them on relevant agendas, conflicts and negotiations with other actors, and dominant designs of the supply systems."*[28]

In addition to the three identified phases in national electricity supply systems, the European level has been complementing these developments with physical interconnection of systems (technical component), but also with institutional maturation and integration (organisational component).[29] The purpose of this chapter is not to provide a detailed and exhaustive historic analysis of electricity supply systems, but to identify and explain the interplay between the technical and the organisational component. While this is the overarching theme of the entire thesis, this chapter provides a brief overview of the development of the electricity sector also by indicating phases (section 2, 3, and 4 of this chapter), however, with a focus on the role of law in the development.

Whereas the very first emergence of electricity systems was in the form of small local systems, the technological sophistication of generation and transmission and growing consumption soon required expansion of the physical system and coordination and cooperation beyond national borders (section 2). Furthermore, main policy objectives to liberalise the electricity sector and to foster a low-carbon electricity society materialised in legislation and have been actively shaping the setting of the electricity sector (section 3). Most recent developments are caused by synergies between the liberalised organisation of the sector, the objective to increase the share RES including of growing amounts of small-scale generation on basis of RES and electrification for

28. Geert Verbong, Erik van der Vleuten, and Martin Scheepers, 'Long-Term Electricity Supply System Dynamics – A Historic Analysis' (2002) Sustelnet Eindhoven (ECN-C—02-084), 16.
29. Similarly to the national phases in electricity supply system developments, three phases of development can be identified on European level, namely: 1915-1950 accidental cooperation, 1950-1990 European network within national institutional boundaries, and 1990-today: crossing institutional boundaries. Geert Verbong, Erik van der Vleuten, and Martin Scheepers, 'Long-Term Electricity Supply System Dynamics – A Historic Analysis' (2002) Sustelnet Eindhoven (ECN-C—02-084), 20.

example by electric vehicles (section 4). Those developments require identifying novel synergies and dynamics between the components of the electricity sector, - technology and organisation, composed of economics and law (subject of the following chapters of this thesis). This chapter lays the cornerstone of this thesis for identifying and analysing legal implications of these developments and unfolds in the following main sections: after this introduction section 2 describes the general setting of the electricity sector by identifying its components. Section 3 analyses the interaction between the components with a focus on the shaping role of law. Section 4 explores recent and ongoing developments in the electricity sector challenging the current organisational setting and more specifically the legal framework. Following the FULDA-method (as outlined in the introduction of this thesis in section 2.4), this chapter concludes that the development of the electricity sector is a reciprocal relationship between technology and organisation which further leads to pointing out the need to rethink the current legal framework of the electricity sector with regard to SES.

2. EVOLUTION - THE SETTING OF THE ELECTRICITY SECTOR

This section identifies the components and describes the evolution of the electricity sector. Understanding both provides a general insight in the setting of the electricity sector and how its current structure evolved. The current electricity sector has been designed to transport electricity from generation to consumption and it mainly developed along growing needs of consumption. Emerging in the late 19th century the first electricity systems were locally constructed to supply single houses and factories. As of 1920, the electricity supply system gradually evolved with increasing generation facilities and sophisticated transmission technology towards an interconnected supply system. With the growing dependence on electricity for societies and nation-building, the construction of electricity networks can be described as

> "[…] *amalgamations of interactions between engineering and nationalism in electric power.* […] *first influences from engineering on nationalism in the way that technologies become tools for nation-building by strengthening the political autarchy of the nation-state, and aiding in construction of national identities, and second, nationalistic influences on engineering in the way that nationalistic objectives come in as support for developing certain technologies."*[30]

30. Mats Friedlund and Helmut Maier, 'The Second Battle of the Currents – A Comparative Study of Engineering Nationalism in German and Swedish Electric Power, 1921-1961' (1996) TRITA-HST Working Paper 96/2, 3.

The increasing dependence on electric power for nation-building and *vice versa* the impact of national policies on the development of the electric supply system exemplify the reciprocal relation between technology and organisation in the development of the electricity sector. Against this background, electricity supply was soon established as a national public utility in European countries.[31] This section further outlines the historic background of the development of the electricity sector in Europe and is structured along the components technology and organisation which is further divided in economics and law.

2.1 Technology Component

Technology is the fundamental component in the electricity sector because, simply speaking, the physical features of electricity cannot be changed. Electric power is the directed movement of electrons in an electric power grid, electricity cables connecting generation with consumption. The electric power has to be generated and the generator needs to be connected to a grid system which transports the electric power to the loads, the final points of consumption. The technical component of an electricity supply system thus entails the following three main parts: generation, transmission/distribution, and consumption of electrical power. Not only do the physical characteristics of electricity determine the design and construction of the system, but the whole sector is largely determined by the physical peculiarities of electricity. This section describes the main technical requirements of a functioning electricity supply system and outlines the emergence of first electricity supply systems. Even though the description of the technical component remains highly limited, a basic outline of the technical determinants of the electricity system is necessary for understanding the need for the organisational component which is outlined in the following section (section 2.2).

As briefly mentioned in the introduction, first electricity systems developed in the end of the 19th century. These systems were typically small-scale local systems which usually served as a lightning system. One of the most famous examples in this regard is the Edison Illuminating Company which built the Pearl Street Power Station in Manhattan, New York City in 1882. The power station served about 500 customers with approximately 10.000 lamps.[32] Mainly, four big companies were involved in the

31. Atle Midttun (ed), *European Electricity Systems in Transition. A Comparative Analysis of Policy and Regulation in Western Europe* (Elsevier Global Energy Policy and Economics Series 1997) 4 and Wolfram Fischer (ed) *Die Geschichte der Stromversorgung* (Verlags- und Wirtschaftsgesellschaft der Elektrizitätswerke m.b.H 1992) 124.
32. Thomas Hughes, 'Edison the Hedgehog: Invention and Development' in Thomas Hughes *Networks of Power: Electrification in Western Society, 1880-1930* (Johns Hopkins University Press 1983) 18-46, 18.

development and expansion of those kind of electricity systems, namely two U.S. American firms *Westinghouse* and *General Electric* and two German firms *Allgemeine Elektricitätsgesellschaft* (AEG) and *Siemens*.

> *"They dominated the industry from 1880 until the 1940s. They had an interest not only in supplying equipment to produce and distribute electricity, but also in providing consumers with traction systems, electro motors, and other appliances".*[33]

The interest of the companies to engage in all parts of the electricity supply system, - generation, distribution, and electric appliances, - exemplifies the strong connection between the technical component and the organisational component which emerged in close relation in the development of electricity supply systems. Originally, electricity systems were deployed and operated locally on the basis of direct current (DC). Direct current entails a one-directional flow of electric current in the electric power grid. With increasing distances of electricity transmission, however, the resistance in the cables leads to electricity losses and thus reduces the efficiency of the supply system. The only option to mitigate electricity losses in DC application is to deploy thicker cables lowering the resistance. Alternating current (AC) provides another solution to the problem of losses reducing the efficiency of the supply system. In contrast to DC, AC alters the direction of flow of the electric current several times within a specified time interval which is specified as frequency. With the need to transmit electricity over longer distances, AC was advantageous over DC as longer distances could be bridged by the ability to transform voltages up and down.[34] The physical functioning of the electricity supply system thus requires the stability and standardisation of two features, namely frequency and voltage.

Frequency only emerged with the development of AC as frequency describes to the number of alternations per second at which AC is generated, measured in Hertz. The frequency of all generators which are connected to the same electricity system have to be standardised. In the beginning of AC development in the late 1880s various frequencies were deployed by various generation companies. First attempts to standardise frequencies occurred on national level. For example, in Germany 25 or 50 Hertz were suggested as standardised frequency in 1903. Yet, despite the aim to establish standardisation, those were only formulated as recommendations:

33. Vincent Langendijk, *Electrifying Europe – The Power of Europe in the Construction of Electricity Networks* (Aksant Academic Publishers Amsterdam 2008) 46.
34. Walt Patterson, *Transforming Electricity* (The Royal Institute of International Affairs 1999) 42.

> *"[…] being aware that these points could not be an object of regulations because this would interfere too much in both the production of various companies and the economic efficiency of the system".*[35]

This indicates that with the development of electricity supply systems by companies also the coordination of operating these emerging systems was entirely left to them. The interconnection of the in parallel developing systems was not yet an issue. However, after the second world war, the reconstruction, expansion, and interconnection of the electricity system required the standardisation of frequencies in Europe. On the initiative of the Organisation for European Economic Cooperation the Union for the Coordination of Production and Transmission of Electricity (UCPTE) was founded in 1951. The founding states included Belgium, Germany, France, Italy, Luxembourg, the Netherlands, Austria, and Switzerland and further extended in the 1980s to Portugal, Spain, former Yugoslavia, and Greece. The original role of UCPTE is described as contributing to the *"development of economic activity through the more effective use of energy resources that was enabled by the interconnection of electricity networks"*.[36] The standardisation of frequency was a precondition to fulfil this role and is now standardised at 50 Hertz.

The second physical feature which is crucial for the functioning of the grid is voltage. Voltage describes the electric tension between two points in an electricity grid. The process of electricity generation creates such tension which can also be described as electric charge.[37] The electric current always flows from a higher charge to the lower charge.[38] Within the grid the voltage level differs. The high voltage network transports the electricity from the point of generation over long distances to transformer stations closer to the loads (the points of consumption). From that point on low voltage networks transport the electricity to the loads. The voltage level at household consumption level is usually standardised so that electric appliances can be developed and safely used. In Europe, the standard voltage is at 230 Volt +/-10%.[39] Voltage and frequency are thus two fundamental physical features of electricity determining the technical requirements and ultimately the technical integrity of the electricity system.

The physical characteristics of electricity also determine the construction of the grid infrastructure. Electricity is the directed movement of electrons in cables. The most distinctive physical feature of electricity is that it cannot be stored itself, but always in

35. Gerhard Neidhöfer, '50-Hz frequency – How the Standard Emerged from a European Jumble', (2011) 9(4) Power and Energy Magazine 66-81, 76.
36. ENTSO-E, "UCPTE/UCTE: The 50 Year Success Story – Evolution of a European Interconnected Grid" (2015) 11.
37. Anthony Pansini, *Guide to Electrical Power Distribution Systems* (6th edn, Fairmont Press 2005) 195.
38. Anthony Pansini, *Guide to Electrical Power Distribution Systems* (6th edn, Fairmont Press 2005) 198.
39. CENELEC (1988). Harmonization Document HD 472 S1.

a different form of energy (for example in chemical, kinetic, or thermostatic energy). Inevitably, the conversion from on to another energy carrier always leads to energy efficiency losses. Avoiding the need for storage and subsequent losses, electricity needs to be consumed at the moment it is produced, thus, the amount of electricity fed into the grid infrastructure needs to equal the amount that is consumed in that moment. This is referred to as electricity system balancing and essential for maintaining the functioning of the electricity supply system. Essentially, balancing entails matching generation with demand in real-time. This also means that for satisfying increasing electricity demand the grid capacity needs to be capable of transporting growing amounts of electricity. Therefore, the calculation of the consumption needs, the load connected to the electricity system, is a decisive factor for the design and the construction of the electricity system, the grid infrastructure. Grid planning takes the connected load, more specifically the highest amount of electric current to be carried by the cables, as starting point for the size of the cables and the generation capacity.[40] Important to emphasise here is that not the total volume is decisive, but the expected peak demands which generally requires oversizing grid capacity in order to also ensure satisfaction of occasional peak demand. This issue is further discussed in chapter 2, section 2.1. The physical features of electricity thus determine the functioning of the electricity supply system in the short-term and the long-term. The short-term determines the stability of the grid infrastructure by means of balancing (matching generation with consumption) and the long-term refers to electricity system planning and capacity calculations to satisfy demand at any time.

The need to standardise technical features such as frequency and voltage already suggest that the technical component of the electricity system needs a component which organises the functioning of the electricity supply system. This section briefly exemplified the interplay between the development and expansion of the electricity system and the establishment of UCPTE in 1951 which was entrusted with the task to coordinate generation and transmission of electricity across European countries. Similarly, the standardisation of voltage needed to be coordinated and standardised. The following sections further elaborate on the quest for an organisational component for a functioning electricity supply system and introduces the organisational component.

2.2 Organisational Component

In contrast to the technical component which is to a large extent predetermined by the physical features of electric power, the organisational component is not static and for the purpose of this thesis comprises the following two sub-components: economics

40. Anthony Pansinsi, *Power Transmission and Distribution* (2nd edn, Fairmont Press 2005) 6.

and law. The economics of electricity supply systems is determined by the network-bound character of the electricity sector. As outlined in the preceding section, electricity supply systems include three main parts, generation, transmission/distribution, and consumption. All three parts are connected by- and depend on the grid infrastructure, the electricity network. The network-bound character further implies the technical need to carefully maintain the balance of the grid, that implies coordinating all connected generators and consumers. The need for coordination of grid usage further leads to the second sub-component, that is law which establishes rules for the use of the electricity system. These rules depend on the technical setting of the electricity supply system and also on broader policy goals related to economic, social or environmental objectives. This section does not outline the legal framework of the electricity sector in detail, that is subject to the following sections 3 and 4 of this chapter. The following two sections focus on the connection between economics and law as part of the organisational component of the electricity sector.

2.2.1 Economics

As mentioned here above, the economic setting of the electricity sector is determined by the network-bound character of the electricity supply system. Network-bound means that all three parts of electricity supply, -generation, transmission/distribution, and consumption are connected to one network. Furthermore, the technical integrity of the grid depends on the standardisation of two main technical features, frequency and voltage, and thus on the compliance of the connected generators and the consumption equipment. These conditions also influenced the economic setting of emerging electricity systems in the beginning of the 20th century. The following observation dating back to 1918 exemplifies the impact of the technical component on the organisational component, specifically the economic setting, as follows:

> *"In contrast to the medley of plants and frequencies in London, the cities of Hamburg and Berlin each have electric [power] supply from a single company. The frequency of the Berlin system is 50 cycles. The business in Paris is [also] practically all in the hands of a single company, operating at 25 and 42 cycles."*[41]

This observation illustrates that in absence of regulation which specifying technical standards, the fewer companies involved in electricity generation connected to the grid, the better the technical integrity of the electricity system regarding frequency. The technical component thus prescribed the market setting of emerging electricity

41. Brooks cited by Gerhard Neidhöfer, '50-Hz frequency – How the Standard Emerged from a European Jumble', (2011) 9(4) Power and Energy Magazine, 66-81, 78.

supply systems. This paved the preconditions for a sector which was dominated only by a few companies operating the entire electricity supply system, from generation, to transmission/distribution and supply.

The technical development of electricity generation plants and the invention of AC and voltage transformers enabled the generation of larger amounts of electricity and the transmission over longer distances with fewer electricity losses. As a result, the economies of scale in the electricity sector changed, as it became more efficient to produce larger amounts of electricity so that smaller production companies disappeared.[42] The extension and connection of several smaller grids towards one network required technical standardisation to diminish uncertainty in supply. Therefore, the electricity sector evolved increasingly into an integrated sector, which included production, transmission/distribution, and supply activities, and the variety of companies in the electricity sector was limited to a few operating companies. One example of how this manifested in practice is the *Rheinisch-Westfälische Elektricitätswerk Aktiengesellschaft* (RWE):

> *"In 1910 and 1920s, RWE built relative large plants of different generation types.* […] *At the same time, a network* […] *was erected to interconnect them.* […] *RWE became a Verbundbetrieb, a united operation through cooperation between interconnected power plants* […]*."*[43]

In addition, the technology of the electricity system also shaped the organisational component by requiring high capital investments in assets resulting in a high threshold for new companies to enter the sector and existing companies needed a specific incentive to venture investments in assets.[44] This phenomenon is known as "natural monopoly" describing the situation in which it is more efficient if one company produces a certain good than for several companies in a competitive market.

> *"More formally, an energy network is a natural monopoly if the costs are sub additive, which means that the total costs of supplying all services needed in a market by one network are below the total costs of producing these services by more than one network."*[45]

42. Caroline Varley and Gudrun Lammers (International Energy Agency) *Electricity Market Reform* (OECD/IEA 1999) 21.
43. Vincent Langendijk, *Electrifying Europe – The Power of Europe in the Construction of Electricity Networks* (Aksant Academic Publishers Amsterdam 2008) 50.
44. Maarten Arentsen and Rolf Künneke, 'Economic Organization and Liberalization of the Electricity Industry' (1996) 24(6) Energy Policy 541-552, 542.
45. Machiel Mulder, 'Economic Regulation of Energy Networks' in Anne Beaulieu, Jaap de Wilde, and Jaquelien Scherpen (eds), *Smart Grids from a Global Perspective: Bridging Old and New Energy Systems* (Springer 2016) 113-126, 115.

The transmission and distribution of electricity is a natural monopoly due to the high fixed costs of the infrastructure. Simply speaking, it is not efficient to have several electricity grids competing in a market setting. This further manifested and reinforced the setting of a few companies dominating the development and operation of electricity supply systems, who could rely on their key position and who enjoyed certainty in recouping investments.

The physical features of the electricity system influenced the organisational component of the sector to a large extent by requiring standardisation for the extension and connection of the grid and by high capital investments in assets. At the same time, electricity became increasingly crucial for the development of national economies and societies. This resulted in vertical integration of electricity supply companies and a central planning structure.[46] However, in contrast to the technical component the organisational setting of the electricity sector can be shaped by legislation. Certainly, law cannot render the network-bound character of electricity, but it can establish rules for the use of the network by assigning rights and responsibilities to actors in the sector. The next section introduces law as a component of the organisational setting of the electricity sector by identifying the main issues requiring regulation.

2.2.2 Law

Generally, law is filled by the intention of the regulatory power (often the government) to shape the behaviour of individuals and companies in a certain way in order to reach a determined objective.[47] First regulations in European countries specifically addressing the electricity sector were characterised by post-first world war rationalisation and increasing the influence of the state on the electricity sector:

> *"The diminishing role of foreign suppliers of capital and equipment coincided with another development: the encroaching influence of governments on electricity production and transmission. Legislation reinforced the influence of the government on the process. Generally speaking, electricity regulation served a variety of purposes: adjusting prices, replacing coal with hydraulic energy, prioritizing national needs, and making electricity a national public service. The latter involved rationalizing national electricity production by prioritizing interconnections, but also by stimulating electrification, especially of the countryside."*[48]

46. Lars Bergman, 'Addressing Market Power and Industry Restructuring' in Jean-Michel Glachant and François Lévêque (eds), *Electricity Reform in Europe – Towards a Single Energy Market* (Edwards Elgar Publishing 2009) 65-88, 65.
47. Kip Viscusi, John Vernon and Joseph Harrington, *Economics of Regulation and Antitrust* (2nd edn MIT Press 2005) 1.
48. Vincent Langendijk, *Electrifying Europe – The Power of Europe in the Construction of Electricity Networks* (Aksant Academic Publishers Amsterdam 2008) 53.

Legislation thus addressed four major issues, namely affordability (*regulating prices*), energy sources (*from coal to hydraulic energy*), ensuring security of supply (*prioritising national needs*), and determining ownership (*national public service*). In addition, in the electricity sector, the quest for regulation was driven by the need to ensure the reliable technical functioning by standardising technical features of the system (see preceding sections). Generally, these objectives of laws addressing the energy sector remained the same over time, however, the means how to reach these objectives changed with technical and political developments. How the legal framework of the electricity sector changed until today is discussed in the following sections of this chapter. How the legal framework might need to change for the purpose of SES is analysed in the following chapters of this thesis.

Against the background of post-first world war rationalisation and increasing state influence on the sector, with the development of technology and the connection of grids only a few companies ruled the sector, from generation, to transmission/ distribution, and supply. Whereas this was initially a development naturally emerging with the companies investing in- and inventing electricity supply systems (such as the example of RWE illustrated), the predominant political interest in European countries to establish electricity supply as a national public service further fostered the setting of a sector with a few companies involved who control the entire electricity supply chain, from generation to transmission/distribution, and supply.

Despite some variations among the European countries in the regimes establishing electricity supply as a national public service, they shared a setting in which the identity between the utility company and government was in close relation (if not the same) and in which supply systems were largely nationally self-containing. The legal frameworks granted those companies the status of vertically integrated public utilities. The economic setting of the sector, the natural monopoly, and the aim to satisfy demand was thus assumed to be in good and responsible hands. Public utilities were either in full control of the whole chain of electricity supply, from generation, to transmission, and supply activities or in control of parts of the chain, for example distribution and supply, forming what is referred to as vertically integrated sector.

3. REVOLUTION 1.0 - SHAPING THE ELECTRICITY SECTOR

The previous section described the components of the electricity sector and identified several links between them. Understanding the electricity sector by approaching and identifying the components addresses the relation between technology and organisation. While the previous section 2 outlined the setting of the electricity sector against the background of the technical emergence of first electricity supply systems and a political landscape characterised by predominant national interests in Europe, this section outlines the role of law in the development of the electricity sector in a more pan-European era.

The European Coal and Steel Community (ECSC), established 1952 by the Paris Treaty, already aimed at creating a common market for coal and steel in order to neutralise competition over natural resources among European countries and thereby preventing the risk for another war in Europe. This is often referred to as the starting point of formal integration of European countries.[49] Integration of European countries however came a long way and is yet still in progress and also contested. This is also exemplified by the development of the EU energy sector. Again, it is not the purpose of this chapter to provide an exhaustive historic overview of the development of EU integration in the energy sector. Instead, the focus is on two main policy objectives which have been initiated on European level and which have been shaping and reshaping the electricity sector in recent decades, namely: the establishment of an internal market for energy (IEM) and the aim to create a low-carbon based energy society. In contrast to the national legal frameworks of the electricity sector in European countries which established the whole electricity supply chain as a monopoly and a national public service, those two policy objectives initiated developments which restructured the organisation of the sector. Liberalisation efforts boosted the number and variation of actors by separating network- and market activities and thereby completely changed the organisational setting. Additionally, strengthened climate change mitigation efforts mainly addressed the choice of energy sources and aimed at emission reductions in the electricity sector. The policy objectives materialised in various legislations which have been adjusted in the course of furthering their achievement. This section describes and analyses these developments and essentially outlines the background of the current legal framework of the electricity sector, which forms the basis for further analysing constraints in the current legal framework for the enabling and incentivising SES.

3.1 Liberalisation

The main goal of the liberalisation of the electricity sector is to establish a competitive market for generation and supply of electricity. Essential for a competitive and free market is that consumers have a choice among various suppliers of electricity.

49. Hans Vedder, Anita Rønne, Martha Roggenkamp, and Iñigo del Guayo, 'EU Energy Law' in Martha Roggenkamp, Catherine Redgwell, Anita Rønne, and Iñigo del Guayo (eds) *Energy Law in Europe – National, EU and International Regulation* (Oxford University Press 2016), 189.

This was not the case prior to liberalisation as usually only one vertically integrated utility generated electricity, operated the national grid system, and also supplied the electricity to the consumer. One of the main aims of liberalisation is therefore to place the consumer more central in the whole electricity supply chain by providing a choice among suppliers. Underlying those major efforts to liberalise the electricity sector is the economic objective to increase overall welfare by improving economic efficiency with a competitive market setting. Following fundamental economic theory, overall welfare is achieved in a perfect market setting. The increase in overall welfare from a monopoly to a competitive market is most obviously reflected in lower supply prices for consumers. Extending the term welfare beyond financial gains, consumers also gain by having a choice among various companies.

Liberalisation can take many different forms and does not necessarily follow the same route. In the European Communities (EC) and later the European Union (EU), the liberalisation of the sector is unique as the process needs to be accompanied by furthering integration of its member states.[50] Whereas single nation states only face their own national electricity sector in the liberalisation process, the liberalisation of the EU electricity sector is accompanied and even requires further integration of the EU member states in order to establish one common market. At the core of a liberalised electricity sector is, however, the separation between network-related tasks and potential market activities. While network-related activities, transmission and distribution of electricity, remain natural monopolies, generation and supply of electricity can be carried out in a competitive market environment. This is referred to as unbundling as the aim is to separate, formally named "unbundle", the electricity supply company in independent segments responsible either for network tasks or generation and supply. Unbundling can take different forms which are explained further below by outlining the process of EU electricity sector liberalisation. However, important to note at this point is that the measure of unbundling only aims at separating network- and market tasks, it does not prescribe the ownership regime. This is in line with article 345 of the Treaty on the Functioning of the European Union (TFEU) stating that *"the Treaties shall in no way prejudice the rules in Member States governing the system of property rights"*. While this is not an obstacle to liberalisation of the electricity sector, it allows member states to follow different reform pathways regarding public- or private ownership regimes in the liberalisation process.[51]

50. Tooraj Jamasb and Michael Pollitt, 'Electricity Market Reform in the European Union: Review of Progress towards Liberalization & Integration', (2005) 26(special issue: European Electricity Liberalization) The Energy Journal 11-41, 11.
51. Ajla Cosic, Lea Diestelmeier, Alexandru Maxim, Tue Anh Nguye, and Nicolò Rosesetto, 'Does Public Ownership provide Affordable and Reliable Electricity to Household Customers? Case Studies of Electricity Sector Reforms in the UK, France, Germany, and Italy' in Massimo Florio (ed) *The Reform of Network Industries – Evaluating Privatisation, Regulation, and Liberalisation in the EU* (Edward Elgar Publishing 2017) 139-156, 140.

The aim to establish a common market was at the core of the EEC and already broadly accepted and implemented when the energy sector was exposed to the idea of establishing an internal market for energy. Reviewing the political and economic efforts to establish an internal energy market in the EU, three main legislative phases can be identified which gradually fostered the way towards the establishment of a competitive IEM.[52] The phases are marked by legislative reforms of the electricity sector on EU level in 1996, 2003, and 2009. At the time of carrying out this research a new legislative proposal for reforming the electricity sector has been published in 2016 and is currently in the EU legislative process. When adopted, this certainly initiates a fourth legislative phase possibly leading to novel organisational settings in the sector. The proposal is discussed in chapter 4 of this thesis against the background of SES functionalities. This chapter, and more specifically this section, sets out the development and the current legal framework of the EU electricity sector. The three legislative phases mainly entailed a complete restructuring of the vertically integrated setting of the companies supplying electricity by separating the sector in network- and market activities and subsequently introducing competitive markets.[53] The liberalisation of the electricity sector needs to be seen as a process, which has still not been completed and continuously needs to be reassessed by observations of the market setting. Understanding the rationale of liberalisation and its implementation in legislation is relevant for this thesis as SES bring new technical functionalities in the electricity supply system which need to be analysed in the light of this liberalised framework. The following sections outline the restructuring process towards a liberalised electricity market in greater detail. After a brief outline of the policy objective to complete the internal market (section 3.1.1), the sections are structured along the two main segments in the sector, namely market activities (section 3.1.2) and system operation (section 3.1.3), additionally, regulatory oversight of the sector became necessary for ensuring the functioning of the market (section 3.1.4).

3.1.1 Completing the Internal Market

The setting of the vertically integrated sector of companies supplying electricity was challenged by the aim to complete the internal market. In 1985, the energy sector was firstly mentioned in a White Paper by the Commission of the EC which identified necessary measures for completing the common market. Among other measures, the directives for public procurement would need to cover several new sectors:

52. The establishment of an internal market for energy in the EU included the oil, gas, and the electricity sector. However, in the context of this chapter the following analysis is restricted to the liberalisation of the electricity sector.
53. Tooraj Jamasb and Michael Pollitt, 'Electricity Market Reform in the European Union: Review of Progress towards Liberalization & Integration' (2005) 26(special issue: European Electricity Liberalization) The Energy Journal 11-41, 13.

> *"Further benefits to Community manufacturers and suppliers accrue from the opening up of tendering for public contracts. By 1988, four major sectors (energy, transport, water and telecommunications) would be included in the system of prior information and publicity."*[54]

Only one year later, the Council of the EC suggested in a resolution that

> *"the aim of any energy policy is to enable consumers to have adequate and secure supplies of energy under satisfactory economic conditions, which is one of the prerequisites for competitive structures and satisfactory economic growth"*.[55]

The main document which is nowadays often referred to as the first formal start of the liberalisation of the energy sector was however published in 1988. This Commission Working Document specifically identified various obstacles for the establishment of the internal energy market.[56] The incumbent setting of the electricity sector which is deeply rooted in national policies was identified as one of the major barriers for establishing the IEM.

> *"The origins of and reasons for these barriers vary a great deal. Most of them are the end-product of domestic rules and regulations originating in an often distant past predating the European idea: this applies for example to all the potential obstacles arising from purely domestic monopolies."*[57]

Additionally, the Commission mentioned technical and political barriers to the internal energy market. This Commission Working Document clearly marks the beginning of the aim to extend the internal market to the energy sector and strongly suggests that the liberalisation of the sector in the European context necessarily requires more integration and hence a stronger legal framework on European level. The document mentions the following four main "sets of actions" to achieve the IEM:

> "[…] *the carrying out of the provisions concerning the energy sector in the 1985 White Book; the determined application by the Commission of the provisions of*

54. Commission of the EC, Completing the Internal Market: White Paper from the Commission to the European Council, COM(85)310, 28-29 June 1985, Annex: Timetable for Completing the Internal Market by 1992, p. 2.
55. Council of the EC, Concerning New Community Energy Policy Objectives for 1995 and Convergence of the Policies of the Member States, (86/C 241/01), 16 September 1986, para 1.
56. Commission of the EC, The Internal Energy Market – Commission Working Document, COM(88)238 final 2, May 1988.
57. Commission of the EC, The Internal Energy Market – Commission Working Document, COM(88)238 final 2, May 1988, para 37.

> *Community Law; the attainment of a satisfactory equilibrium energy/environment; the definition of appropriate means, to be selected case by case, in areas specifically related to energy policy."*[58]

While these "sets of actions" appeared ambitious, they remained limited, as legal measures to achieve them were confined to existing Community law as there was no sector specific legislation yet. Liberalisation is not an objective itself, but a measure to increase overall welfare by improving efficiency with a competitive market setting. Maintaining the competitive market setting in a network-bound sector requires the legal framework to establish a level-playing field ex ante by establishing rules for the use of the system, sector specific legislation. Only then can potential users of the network know the rules for using the network. Sector specific legislation was introduced in 1996 in the electricity sector. Since then, the main measures enabling market opening are unbundling the vertically integrated companies and establishing rules for access to the electricity system. Both measures (unbundling and access rules) are explained in greater detail below. Despite sector specific legislation, the network-bound character of the sector remains very sensitive to illegal behaviour of actors seeking to manifest and exploit their key position.[59] In the context of completing the internal market by widening liberalisation to the energy sector, competition law remains a crucial tool for ensuring a level-playing field across the EU member states mainly by state aid control and rules on public undertakings.[60]

The following sections describe the impact of liberalisation on the different segments of the electricity sector. Liberalisation introduced a division between market- and grid- related tasks. Additionally, this gradual evolution from vertical integration towards a liberalised organisational setting eventually required regulatory oversight of the electricity sector. The following sections describe the three legislative phases of liberalisation of the electricity sector along those divisions (market opening, system operation, and regulatory oversight).

3.1.2 Market Opening

The vertically integrated setting of the sector did not allow for distinguishing between different activities in the electricity supply chain, as generation and supply

58. Commission of the EC, The Internal Energy Market – Commission Working Document, COM(88)238 final 2, May 1988, para 38.
59. Hannah Kruimer, *The Non-Discrimination Obligation of Energy Network Operators – European Rules and Regulatory Practice* (Energy & Law Series Intersentia 2013) chapter 2 'The Reasons why Network Operators have a Non-Discrimination Obligation' 17-42.
60. Hans Vedder, 'Competition in the EU Energy Sector – an Overview of Developments in 2009 and 2010' in Martha Roggenkamp and Ulf Hammer (eds) '*European Energy Law Report VIII*' (Energy & Law Series Intersentia 2011) 3-20, 16.

were commonly integrated with transmission and/or distribution. A precondition to distinguish electricity generation and supply from the transmission and/or distribution of electricity was to recognise electricity as a good. Prior to liberalisation, electricity supply was considered as public service, carried out by public utilities. This perception was also justified by the network-bound character of electricity and the need to balance generation with consumption at all times. The underlying reasoning stressed that *"electrical energy is an intangible commodity that must be produced as it is consumed, which confers on it one of the typical characteristics of a service"*.[61] Essentially, the physical characteristics of electricity are allegedly providing reasons for organising the whole electricity supply chain as vertically integrated public service.[62] Legally the contrary has been established several times, pointing out that *"electrical energy has many functions of the same kind as oil or gas, the 'goods' characteristics of which have never been questioned (and which directly compete with electricity)"*.[63] The classification of electricity as a good was established in the case *Flaminio Costa v ENEL* and was consistently reaffirmed.[64] Classifying electricity as a good was a necessary precondition which allowed separating the generation and supply of a product (electricity) from the service of its transport (transmission and distribution). The legal tool to separate the product (electricity) and the service (transmission and distribution) is unbundling. Unbundling means separating potential market activities from network-related tasks which is a precondition for opening a market for electricity generation and supply. In the three legislative phases on EU level, unbundling was gradually strengthened. This section outlines the introduction of unbundling, the impact on the market, and how it has been reformed in the course of the legislative phases.

Unbundling was initiated in 1996 by the first legislative phase in the Directive concerning common rules for the internal market in electricity (hereafter: Directive 1996/92).[65] Directive 1996/92 required the minimum of what is defined as "administrative unbundling". Administrative unbundling provides only a limited degree of unbundling because the integrated companies are merely required to keep separated accounts for their different activities (generation, transportation, supply); however, they still form an

61. Andras Lakatos, 'Overview of the Regulatory Environment for Trade in Electricity' in Janusz Bielecki, Melaku Desta (eds) *'Electricity Trade in Europe – Review of the Economic and Regulatory Challenges'* (Kluwer Law International 2004) 119-154, 124.
62. See reasoning of the Italian Government in C-158/94 *Commission v Italy* [1994] ECR-I 5789, para 14.
63. Andras Lakatos, 'Overview of the Regulatory Environment for Trade in Electricity' in Janusz Bielecki, Melaku Desta (eds) *'Electricity Trade in Europe – Review of the Economic and Regulatory Challenges'* (Kluwer Law International 2004) 119-154, 124.
64. C-64/4 *Costa vs ENEL*, C-393/92 *Almelo and Others vs Energiebedrijf IJsselmij* [1992] ECR-I 1508, para 28 C-158/94 *Commission vs Italy* [1994] ECR-I 5789, and C-573/12 *Ålands Vindkraft AB vs Energimyndigheten* ECJ (1 July 2012).
65. Directive (EC) No 1996/92 Concerning Common Rules for the Internal Market in Electricity [1997] OJ L27/20. In the following Directive 1996/92/EC.

integrated undertaking.[66] The limited degree of unbundling also resulted in different definitions of generators. Whereas the activity of generation was simply defined as *"the production of electricity"*,[67] three definitions differentiate the term "producer". Firstly, and most straightforward the Directive defines that a *"'producer' shall mean a natural or legal person generating electricity"*.[68] The Directive further distinguishes that *"'autoproducer' shall mean a natural or legal person generating electricity essentially for his own use"*.[69] And lastly, with regard to the limited degree of unbundling the Directive also specifies that

> *"'independent producer' shall mean: (a) a producer who does not carry out electricity transmission or distribution functions in the territory covered by the system where he is established [and] (b) in Member States in which vertically integrated undertakings do not exist and where a tendering procedure is used, a producer corresponding to the definition of point (a), who may not be exclusively subject to the economic precedence of the interconnected system".*[70]

The distinction shows that the unbundling of generation and grid operation was not a strict separation which consequently did not lead to a competitive market for electricity generation and supply. Similarly, electricity supply was defined as *"the delivery and/or sale of electricity to customers"*.[71] This definition still allowed electricity supply to be integrated with transmission and distribution of electricity.

Directive 1996/92 resulted in different degrees of market opening, distorting competition among the member states. This was also recognised by a Communication of the Commission proposing amendments to Directive 1996/92 and proposing the adoption of new legislation.[72] The new Directive entered into force in 2003 (hereafter: Directive 2003/54)[73] and aimed at further harmonising electricity sector regulation among the member states in order to strengthen competitive market forces.[74] To this end, Directive 2003/54 established stronger separation between the activities of the electricity supply chain by setting stricter unbundling requirements, namely legal

66. Art. 14(3) Directive 1996/92/EC.
67. Art. 2(1) Directive 1996/92/EC.
68. Art. 2(2) Directive 1996/92/EC.
69. Art. 2(3) Directive 1996/92/EC.
70. Art. 2(4) Directive 1996/92/EC.
71. Art. 2(16) Directive 1996/92/EC.
72. Commission of the EC, 'Communication from the Commission to the Council and the European Parliament – Completing the Internal Energy Market – Proposal for a Directive amending Directives 96/92/EC and 98/30/EC concerning Common Rules for the Internal Market in Electricity and Natural Gas – Proposal for a Regulation on Conditions for Access to Network for Cross-Border Exchange in Electricity', COM(2001)125 final, 13 March 2001.
73. Directive (EC) No 2003/54 Concerning Common Rules for the Internal Market in Electricity and repealing Directive 96/92/EC [2003] OJ L176/37. In the following Directive 2003/54/EC.
74. Tilman Dralle, 'The Unbundling and Unbundling-Related Measures in the EU Energy Sector' in *Ownership Unbundling and Related Measures in the EU Energy Sector European Yearbook of International Economic Law* 5 (Springer 2018) 21-63, 22.

and functional unbundling.[75] Legal unbundling required separate legal entities for transmission of electricity and production and supply.[76] However, this did not mean that the undertaking needed to be split the ownership of transmission and other activities. Legal unbundling was supplemented by functional unbundling which additionally required effective separation of organisation and decision making. This was elaborated in a variety of detailed rules. For example, persons working in the management of transmission system operation were not allowed to work in a part of the vertically integrated undertaking responsible for the generation, distribution, and supply of electricity.[77] Still, the extent of unbundling was limited because the ownership of assets remained untouched, as it is clearly stated in the unbundling requirements for the transmission system:

> "…*it* [the transmission system operator] *shall be independent at least in terms of its legal form, organisation and decision making from other activities not relating to transmission. These rules shall not create an obligation to separate the ownership of assets of the transmission system from the vertically integrated undertaking".*[78]

The definition of "producer" was adjusted and the Directive only contained one definition, namely *"'producer' means a natural or legal person generating electricity"*.[79] In contrast to the previous directive which included various definitions of electricity producers, this definition clarified that electricity generation was not integrated anymore with transmission or distribution activities. Another important change regarding the establishment of the electricity market was introduced by Directive 2003/54 by accelerating the development of customers by declaring all non-household customers to be eligible customers from July 2004 and even all consumers by July 2007.[80] "Eligible customer" entails the right to freely purchase electricity from the supplier of own choice.[81] Granting consumers the right to freely choose their supplier is a necessary precondition for furthering competition in electricity supply.

Regulatory shortcomings regarding the further establishment of the internal energy market have been identified by the Commission in a sector enquiry published in 2007.[82] The following main deficits have been mentioned: high market concentration, vertical foreclosure, insufficient market integration between member states, lack of transparency

75. Art. 10 Directive 2003/54/EC.
76. Art. 10(1) Directive 2003/54/EC.
77. Art. 10(2)(a) Directive 2003/54/EC.
78. Art. 10(1) Directive 2003/54/EC.
79. Art. 2(2) Directive 2003/54/EC.
80. Art. 21 Directive 2003/54/EC.
81. Art. 2(12) Directive 2003/54/EC.
82. European Commission, Energy Sector Enquiry, SEC (2006) 1724, 10 January 2007.

and information, disturbed price setting.[83] Based on those findings the third legislative phase was initiated and resulted in a set of Directives and Regulations which were adopted in 2009.[84] In its sector enquiry preceding the legal reform, the Commission suggested to *"decisively reinforce the current inadequate level of unbundling"*.[85] This resulted in the preferred option of ownership unbundling, meaning that the same legal person cannot exercise "control" or "any rights" over a transmission system and generation and supply companies.[86] Even though ownership unbundling was the proposed legal measure for further separating market- and network realms in the electricity supply chain, as a result of a political compromise the final version of Directive 2009/72 contains the following three options which allow for some deviation in the form of system operation: full ownership unbundling (the preferred option), the independent system operator (ISO), and the independent transmission operator (ITO). Despite some variations in the degree of unbundling between the three models, all options must provide the same effect, namely ensuring that the same legal person cannot exercise control over a generation and a supply company and a transmission system. The resulting regulatory choice left to the member states led to different implementations at national level.[87] By 2013 about 80% of the existing TSOs in the EU completed the unbundling process, the decisions of the EU Commission issued in the certification process of TSOs provide further insights in the exact interpretation of the unbundling rules.[88]

83. European Commission, 'Energy Sector Enquiry', SEC (2006) 1724, 10 January 2007, 5 - 7.
84. The third legislative phase, often referred to as "Third Energy Package", of the European internal energy market includes two Directives on common rules for the internal market in electricity and gas (2009/72/EC and 2009/73/EC) and three Regulations, one establishing ACER (No 713/2009) and two Regulations on the conditions for access to the electricity and natural gas transmission networks (No 714/2009 and No 715/2099).
85. European Commission, Energy Sector Enquiry, SEC (2006) 1724, 10 January 2007, 12.
86. "Control" is defined by Art. 2(34) Directive 2009/72/EC as *"rights, contracts or any other means which, either separately or in combination and having regard to the considerations of fact or law involved, confer the possibility of exercising decisive influence on an undertaking, in particular by: (a) ownership or the right to use all or part of the assets of an undertaking; (b) rights or contracts which confer decisive influence on the composition, voting or decisions of the organs of an undertaking"*. "Rights" is defined by Art. 9(2) Directive 2009/72/EC as *"the power to exercise voting rights; (b) the power to appoint members of the supervisory board, the administrative board or bodies legally representing the undertaking; or (c) the holding of a majority share."*
87. Eckart Ehlers, *Electricity and Gas Supply Network Unbundling in Germany, Great Britain and The Netherlands and the Law of the European Union: A Comparison* (Energy & Law Series 9 Intersentia 2010) and Martha Roggenkamp, 'Full Transparency through Ownership Unbundling: Ownership Unbundling of Transmission and Distribution Grids in The Netherlands' in Martha Roggenkamp and Ulf Hammer (eds) *European Energy Law Report VI* (Energy & Law Series 8 Intersentia 2009) 61-76.
88. Nicolaas Bel and Ruben Vermeeren, 'Unbundling in the EU Energy Sector – The Commission's Practice in Assessing the Independence of Transmission System Operators for Electricity and Gas' in Martha Roggenkamp and Henrik Bjørnebye (eds) *European Energy & Law Report X* (Energy & Law Series 8 Intersentia 2014) 49-64, 52.

The legal options aiming at ownership unbundling (or at least preventing control of the same legal person over generation and network activities) are only applicable to the TSO and not to the DSO. The latter one is still only subject to legal and functional unbundling.[89] Directive 2009/72 states:

> *"non-discriminatory access to the distribution network determines downstream access to customers at retail level. The scope for discrimination as regards third-party access and investment, however, is less significant at distribution level than at transmission level where congestion and the influence of generation or supply interests are generally greater than at distribution level* [...]*".*[90]

The stricter regulatory provisions applicable to the transmission system in comparison to the distribution system can be explained by the fact that most electricity generation is connected to the transmission system. Therefore, the unbundling of transmission system operation from generation activities is considered more significant than the unbundling of DSOs. Furthermore, DSOs sometimes serve only a relatively small number of connected customers. Directive 2009/72 even allows full exemption from the unbundling requirements in case DSOs serve *"less than 100.000 connected customers, or serving small isolated systems"*[91] as the impact on distortions of the internal market is considered insignificant. This exemplifies that the legal framework is tailored to a technical setting of the electricity sector in which most generation is connected to the transmission grid level. The core of this thesis elaborates on technical developments at distribution grid level, such as small-scale generation on basis of variable RES connected to the distribution grid and increasing electrification. These developments not only need to be technically integrated, but also the legal framework needs to be elaborated for activities at distribution grid level. The following two sections outline the current legal further by explaining implications of liberalisation for system operation (section 3.1.3) and the need for regulatory oversight (section 3.1.4).

3.1.3 System Operation

The preceding section outlined the development of unbundling which enabled electricity generation and supply to become market activities. However, unbundling vertically integrated companies is not sufficient for ensuring a competitive market setting. As the electricity sector is a network-bound sector, system users need access to the grid infrastructure in order to participate in the market. Therefore, and additionally

89. Art. 26 Directive (EC) No 2009/72 Concerning Common Rules for the Internal Market in Electricity and repealing Directive 2003/54/EC [2009] OJ L211/55. In the following Directive 2009/72/EC.
90. Recital 26 Directive 2009/72/EC.
91. Art. 26(4) Directive 2009/72/EC.

to unbundling, it is also necessary to ensure that system operators provide access to the system in principle to all system users seeking access. Rules for accessing the electricity system are necessary for preventing system operators from abusing their natural monopoly position in favouring their related generation and supply undertakings to access the grid.[92]

Similar to the legal measure regarding unbundling, rules for providing access to the electricity system have been changing with the legislative phases of the liberalisation process. Directive 1996/92 offered the following three different access models: Negotiated access, regulated access, and the single buyer procedure.[93] Negotiated access means that system users need to negotiate access conditions with the system operator. For the sake of transparency, the directive also required system operators to publish *"an indicative range of prices for the use of transmission or distribution systems"* which should be based on the average prices agreed upon in the preceding 12-months period.[94] This provided a safeguarding measure preventing system operators to charge extraordinary high prices for system use. Regulated access implied the right for eligible customers to access the system on basis of published tariffs. However, eligible customers were a very limited group under that directive which was determined by consumption threshold calculations.[95] Refusing access was only allowed in case of lacking capacity and *"duly substantiated reasons must be given for such refusal"*[96] (such reasons are explained further below in this section). In the single-buyer model member states designate a legal person to be the single buyer of electricity within the territory covered by the system operator.[97] Again, only eligible customers and independent producers were free to negotiate access. The models implied large differences in market opening and did not provide a level-playing field for system users seeking access to the electricity system.

The variety of access models soon became an obstacle to the further development of the liberalisation because different rules were applicable across the member states.[98] The second legislative phase with Directive 2003/54 abolished the choice of access models

92. Hannah Kruimer, *The Non-Discrimination Obligation of Energy Network Operators – European Rules and Regulatory Practice* (Energy & Law Series 15 Intersentia 2013) and Alexander Kotlowski, 'Access Rights to European Energy Networks – A Construction Site Revisited' in Bram Delvaux, Michaël Hunt and Kim Talus (eds) *EU Energy Law and Policy Issues – ELRF Collection*, (2nd edn Intersentia 2009).
93. Art. 16-18 Directive 1996/92/EC.
94. Art. 17(3) Directive 1996/92/EC.
95. Art. 19 Directive 1996/92/EC.
96. Art. 17(5) Directive 1996/92/EC.
97. Art. 2(22) Directive 2003/54/EC defines the single buyer as *"any legal person who, within the system where he is established, is responsible for the unified management of the transmission system and/or for centralized electricity purchasing and selling"*.
98. Leonardo Meeus, Konrad Purchala, and Ronnie Belmans, 'Development of the Internal Electricity Market in Europe' (2005) 18(6) The Electricity Journal, 25-35, 27.

and required member states to implement the same model, namely non-discriminatory regulated third-party-access (TPA).[99] Essentially, non-discriminatory access implies that all system users, who are natural or legal persons supplying to, or being supplied by a transmission or distribution system, are charged a non-discriminatory tariff for their system use.[100]

> *"Member States shall ensure the implementation of a system of third party access to the transmission and distribution systems based on published tariffs, applicable to all eligible customers and applied objectively and without discrimination between system users. Member States shall ensure that these tariffs, or the methodologies underlying their calculation, are approved prior to their entry into force in accordance with Article 23 and that these tariffs, and the methodologies* [. . .] *are published prior to their entry into force."*[101]

The EU Commission further clarifies this provision by stating

> *"non-discriminatory access implies, for example, that neither size, the relationships between suppliers and network operators, nor portfolio considerations in the case of large system users must affect the tariffs and other conditions. This implies that tariff systems should not contain structural elements, such as distance related charges, which tend to discriminate, for example, against companies with a small portfolio".*[102]

Underlying the need for rules establishing the access to the system is the fact that the grid is an essential facility for participating in the market. As established in *Bronner*, refusing access to the essential facility can only be justified by objective reasons.[103] Regarding the electricity sector, this was further confirmed in *VEMW* by emphasising the duty of system operators to grant access.[104] One of the objective justifications for system operators to deny access to its system is lacking capacity. Directive 2009/72 states *"the transmission or distribution system operator may refuse access where it lacks the necessary capacity"*.[105] Another objective reason was provided by the Directive on the promotion of the use of

99. Art. 20 Directive 2003/54/EC.
100. Art. 2(18) Directive 2003/54/EC.
101. Art. 20(1) Directive 2003/54/EC.
102. Commission of the EC (2005), Technical Annex to the Report from the Commission to the Council and the European Parliament on Progress in Creating the Internal Gas and Electricity Market. COM (05)568 final. Brussels, 2005 9.
103. C-7/97 *Oscar Bronner GmbH & Co. KG v Mediaprint Zeitungs- und Zeitschriftenverlag GmbH & Co. KG* [1998] ECR I-07791, para. 25.
104. C-17/03 *Vereniging voor Energie, Milieu en Water, Amsterdam Power Exchange Spotmarket BV, Eneco NV v Directeur van de Dienst uitvoering en toezicht energie* [2005] ECR I-04983, para. 46.
105. Art. 32(2) Directive 2009/72/EC.

energy from renewable sources.[106] The Directive provided for priority access for RES to the grid and thus distinguished between qualities of electricity. The directive states that *"Member States shall also provide for either priority access or guaranteed access to the grid-system of electricity produced from renewable energy sources"*.[107] This clearly shows that exemptions from the general principle of non-discriminatory TPA are possible but only in cases where the Directive provides for derogations: *"that margin of discretion does not authorize them* [member states] *to depart from that principle* [of non-discrimination] *except in those cases where the Directive lays down exceptions or derogations"*.[108] The non-discrimination obligation is not a goal in itself, and therefore not absolute, but a tool to ensure a competitive market setting. This also means that

> *"the non-discrimination obligation for system operators does not strive to reach absolute equality of system users. Non-discriminatory behaviour by the monopoly system operators aims at equality of system users to the extent necessary to 'facilitate competition between the competitive market participants'".*[109]

Next to the objective of establishing a competitive market for generation and supply of electricity, other objectives need to be ensured too. This requires balancing the overall objectives and finding solutions, for example in the form of exemptions, to facilitate the co-existence of conflicting objectives. Facilitating competition in generation and supply on the one hand, and incentivising RES (by providing priority access to the system) on the other hand presents an example of such conflicting objectives. Section 3.2 of this chapter further discusses the objective of establishing a low-carbon electricity sector.

As a consequence of allowing all system users to access the electricity system ensuring the technical integrity of the electricity system required additional regulation. This resulted in the establishment of network codes, common rules on specific issues concerning the operation and the market of the electricity system. The development of network codes under the third legislative phase is an innovative procedure and a response to gradual interconnection of the grid system in Europe and the establishment of the IEM. The regulation on conditions for access to the network for cross-border exchanges in electricity (hereafter: Regulation 2009/714)[110] establishes the procedure

106. The Directive is discussed in the following section in more detail in the context of the promotion of electricity generated from renewable energy sources.
107. Art. 16(2b) Directive 2009/28/EC.
108. C-439/06 *Citiworks AG* [2008] ECR I-03913, para. 55.
109. Hannah Kruimer, 'Non-Discriminatory Energy System Operation: What Does It Mean?', (2011) 3 Competition and Regulation in Network Industries 260-286, 274.
110. Regulation (EC) No 2009/714 on Conditions for Access to the Network for Cross-Border Exchanges in Electricity and repealing Regulation (EC) No 1228/2003 [2009] OJ L211/15. In the following Regulation (EC) No 2009/714.

which involves various actors.[111] European TSOs, represented by the European Network for Transmission System Operators for Electricity (ENTSO-E), play an important role in the drafting process.[112] With an increasing number of TSOs and the overall aim to interconnect the grids and establish an internal market, the involvement of TSOs is crucial for the operability of the grids across borders. Not at least because electricity brown- or blackouts in Europe mainly occurred due to technical failures and not due to shortcomings in generation capacity.[113]

The legislative phases of the EU electricity sector liberalisation strongly affected the entire organisational component of the electricity sector. Unbundling vertically integrated electricity supply undertakings was a necessary condition for opening up the market for generation and supply. Supplementing unbundling, rules for accessing the electricity system aimed at ensuring that system operators provide system users with transparent and non-discriminatory conditions for system use. While these rules aimed at increasing the overall welfare of the sector, the rules also increased the complexity of the organisational component by introducing more actors for market- and network activities. Moreover, this complexity is even amplified by variations in the liberalisation process among different member states in the EU which yet are all subject to the integration in one common internal energy market. Maintaining and furthering the process of liberalisation in this complex context required supervision and evaluation of the development of the sector. The following section introduces how the quest for regulatory oversight was implemented.

3.1.4 Regulatory Oversight

Prior to liberalisation usually only one vertically integrated undertaking was in control of the entire electricity supply chain. In contrast, the liberalised electricity sector comprises and even requires many more actors in the sector, those are producers, TSOs, DSOs, suppliers, and various categories of consumers. The increased number of actors with varying interests in the sector bring about potential conflicts and subsequent misconduct. This was already anticipated in the first legislative phase and Directive 1996/92 therefore established that

111. See an illustration of the involved actors and the procedure in Hans Vedder, Anita Rønne, Martha Roggenkamp, and Iñigo del Guayo, 'EU Energy Law' in Martha Roggenkamp, Catherine Redgwell, Anita Rønne, and Iñigo del Guayo (eds) *Energy Law in Europe – National, EU and International Regulation* (Oxford University Press 2016), 277.
112. Steven de Moel and Florence Melchior, 'Cooperation Between TSOs: Background, Organisation and Netcodes' in Martha Roggenkamp and Ulf Hammer (eds) *European Energy law report VIII* (Energy & Law Series 12 Intersentia 2011) 21-42.
113. Tooraj Jamasb and Michael Pollitt, 'Security of Supply and Regulation of Energy Networks' (2008) 36 Energy Policy, 4584–4589, 4585.

> *"Member States shall designate a competent authority, which must be independent of the parties, to settle disputes relating to the contracts and negotiations in question. In particular, this authority must settle disputes concerning contracts, negotiations and refusal of access or refusal to purchase."*[114]

While the authority mentioned in Directive 1996/92 was mainly assigned the task to settle disputes, Directive 2003/53 introduced further competences and classified the authorities as national regulatory authorities (NRA).[115] Recital 15 of Directive 2003/54 states:

> *"The existence of effective regulation, carried out by one or more national regulatory authorities, is an important factor in guaranteeing non-discriminatory access to the network. Member States specify the functions, competences and administrative powers of the regulatory authorities. It is important that the regulatory authorities in all Member States share the same minimum set of competences"*

However, the subsequent legal provisions did not require the regulatory authority to be fully independent from relevant bodies in the member state, which left some discretion to governmental bodies and hence did not fully ensure the regulatory oversight being truly independent.[116] The introduction of regulatory oversight in form of competent authorities on member state level added new actors to the organisational setting of the electricity sector. As the NRAs were established for supervising the functioning of the competitive electricity sector, enhancing liberalisation required strengthening their role. This was facilitated by the third legislative phase as Directive 2009/72 explicitly required the NRA to be legally distinct from any other public or private party.[117] Ensuring this, Directive 2009/72 further required that

> *"the regulatory authority can take autonomous decisions, independently from any political body, and has separate annual budget allocations, with autonomy in the implementation of the allocated budget, and adequate human and financial resources to carry out its duties".*[118]

114. Art. 20(3) Directive 1996/92/EC.
115. Art. 23 Directive 2003/54/EC.
116. Art. 23(3) Directive 2003/54/EC.
117. Art. 35(4a) Directive 2009/72/EC.
118. Art. 35(5a) Directive 2009/72/EC.

Despite the explicit condition that the regulatory authority needs to take decisions independently, the implementation of the concept independence varies between the national jurisdictions and illustrate that independence of supervisory bodies is *"a fragile concept"*.[119]

Next to strengthening the independent role of the NRAs, the third legislative phase also recognised the increasing need for cooperation among member states on regulatory oversight. Underlying the need for more cooperation was the integration of the electricity sector. The liberalisation of the electricity sector in Europe did not only strive for a liberalisation of national markets, but also required the establishment of an internal market within the EU. In addition to the unbundling of national electricity supply utilities cooperation between the member states aimed at ensuring that the same conditions of the organisational setting are applicable and implemented throughout the member states. Therefore, the third legislative phase facilitated cooperation of NRAs by establishing the Agency for the Cooperation of Energy Regulators (ACER).[120]

ACER is classified as regulatory agency with legal personality and institutionalises the cooperation of energy regulators at European level.[121] ACER has various monitoring tasks[122] and may *"provide an opinion or a recommendation to the European Parliament, the Council and the Commission on any of the issues relating to the purpose for which it has been established"*.[123] One of ACER's tasks is being involved in the drafting of network codes (see previous section 3.1.3) and monitoring their implementation.[124] In the drafting process ACER provides *"non-binding framework guideline* […] *setting out clear and objective principles,* […] *for the development of network codes"* on basis of which European Network of TSOs for electricity (ENTSO-E) needs to develop a network code.[125] The establishment of ACER shows that the liberalisation of the electricity sector in the EU is accompanied by the quest for an integrated electricity sector which requires common standards and joint monitoring, and cooperation in both. However, it can be argued that the basis of ACER is still strongly influenced by national bases as it originates from NRAs which could have a negative impact on the role of a truly European control.[126] Overall,

119. Saskia Lavrijssen, 'Independent Supervisory Authorities: A Fragile Concept' (2012) 39(4) Legal Issues of Economic Integration 419-446, 431.
120. Regulation (EC) No 2009/713 Establishing an Agency for the Cooperation of Energy Regulators [2009] OJ L211/1. In the following Regulation (EC) No 2009/713.
121. Art. 2 Regulation (EC) No 2009/713.
122. Art. 6 Regulation (EC) No 2009/713.
123. Art. 5 Regulation (EC) No 2009/713.
124. Art. 6(4-6) Regulation (EC) No 2009/713.
125. Claude-Albane Swanson, 'The Agency for Cooperation of Energy Regulators' in Martha Roggenkamp and Ulf Hammer (eds) *European Energy Law Report VI* (Energy & Law Series 8 Intersentia 2009) 37-50, 45.
126. Saskia Lavrijssen and Leigh Hancher, 'Networks on Track: From European Regulatory Networks to European Regulatory "Network Agencies"' (2008) 34(1) Legal Issues of Economic Integration 23-55, 28.

the legislative phases of the liberalisation enabled the development of many more actors in the electricity sector and gradually strengthened their roles, responsibilities, and rights. Compared to the setting of the electricity sector prior to liberalisation, this development is not merely based on security of supply efforts, but increasingly focused on an overall gain in welfare and cooperation by means of introducing a competitive market to the extent possible in a network-bound sector. Next to the establishment of a competitive internal energy market another major policy objective gradually shaped the electricity sector on EU level, namely the aim to mitigate climate change by reducing emissions from the energy sector and to reduce fuel dependency from third states. The following section elaborates on this objective and thereby further explores the role of law in the development of the EU electricity sector.

3.2 Climate Change Mitigation

The process of generating electricity on basis of fossil fuel sources, such as coal, natural gas, and oil releases carbon dioxide (CO_2). Increased concentrations of CO_2 are polluting the air and is highly harmful to the environment as a whole. Other air pollutant gases are also released which are often summarised as Green House Gases (GHG) as they cause the “greenhouse effect” on planet Earth resulting in raising temperatures and various other hazardous living conditions.[127] This is commonly referred to as climate change. Throughout different fields, science, politics, and law, it is widely accepted that climate change is a global problem and therefore needs to be addressed on international or at least on regional level. The European efforts to reduce GHG emissions thus have an external- and an internal dimension.

The external dimension needs to be seen in the context of global efforts to mitigate climate change. The United Nations Secretariat for the Framework Convention on Climate Change (UNFCCC) is the most prominent and most well-established international approach to combat climate change on international level.[128] The Convention sets general rules and objectives to combat climate change. On the basis of the UNFCCC, the parties adopted in 1997 an international binding agreement to reduce GHG emissions by 5% compared to 1990 by 2012. This international agreement is well-known as the Kyoto Protocol and despite vast criticism has often been referred to as major achievement to

127. The Intergovernmental Panel on Climate Change (IPCC) is the United Nations body for assessing the science related to climate change. In 2018, the IPCC, published a special report on the impacts of global warming. IPCC, Global warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty.
128. See for background and current developments on the UNFCCC www.unfccc.int.

combat climate change on global level and as "*a political necessity*".[129] The most recent agreement under the UNFCCC is the Paris Agreement functioning as a successor for a second commitment period which was adopted in 2015. The actual effectiveness of those international agreements has however been contested extensively because they lack enforcement measures and in practice are rather loose. One of the main reasons why the reduction of GHG emissions is such an extremely difficult task is that private parties who are the main emitters need to invest in other technologies or need to reduce energy consumption. Both options imply costs that can hardly be recouped. International agreements, even with binding character, can only set targets for the parties who signed. The actual enforcement is thus up to the states which are party to the agreement and who need to justify measures nationally against the claim of the industry that international competitiveness is at stake when establishing obligations regarding GHG emission reductions. Inevitably, this results in a dilemma between international economic competitiveness and climate change mitigation measures.[130] An attempt to minimise this dilemma by the EU is to integrate climate change in the realm of external relations and thereby bind third partners to obligations too.[131] The energy sector is one of the largest emitters of GHG and therefore part of the problem and the solution at the same time. Expectedly, the energy sector thus has a strategic role for implementing the Paris Agreement and achieving its set goals.[132] The implementation however takes place on the national, or regional level, leading to the internal dimension of EU climate change mitigation and more specifically, the aim to reduce emissions from the energy sector in the EU.

Internally, EU commitments to combat climate change by reducing GHG emissions have brought up various legislations implementing different measures, for example legislation establishing the European Emission Trading Scheme (EU ETS),[133] aiming at

129. Joanna Depledge and Farhana Yamin, 'The Global Climate Change Regime – A Defence' in Dieter Helm and Cameron Hepburn (eds), *The Economics and Politics of Climate Change* (Oxford University Press 2009) 1-29, 26.
130. This dilemma became evident in the discussion about the implementation of the European Emission Trading Scheme. For a detailed discussion on this issue see Harro van Asselt and Frank Biermann, 'European Emissions Trading and the International Competitiveness of Energy-Intensive Industries: a Legal and Political Evaluation of Possible Supporting Measures' (2007) 35(1) Energy Policy 497-506 and David Pocklington, 'European Emission Trading – The Business Perspective' (2002) 11(7) European Energy and Environmental Law Review 209-218.
131. Hans Vedder, 'The Formalities and Substance of EU External Environmental Competence: Stuck between Climate Change and Competitiveness' and Kati Kulovesi, 'Climate Change in EU External Relations: Please Follow My Example (or I might Force You to)' both in Elisa Morgera (ed) *The External Environmental Policy of the European Union* (Cambridge University Press 2012).
132. Catherine Banet, 'The Paris Agreement to the UNFCCC: Underlying Dynamics and Expected Consequences for the Energy Sector' in Martha Roggenkamp and Catherine Banet (eds) *European Energy Law Report XI* (Energy & Law Series Intersentia 2017) 71-91, 82.
133. Directive 2003/87/EC Establishing a Scheme for Greenhouse Gas Emission Allowance Trading within the Community and amending Council Directive 96/61/EC [2003] OJ L275/32. In the following Directive 2003/87/EC.

improvements in energy efficiency,[134] regulating carbon capture and storage (CCS),[135] the promotion of biofuels in the transport sector, and also the promotion of electricity from RES.[136] Addressing the energy sector in particular with these measures is of special importance, as the European Environment Agency (EEA) estimates that about 78% of all released GHG in the EU(28) stem from the energy sector in 2016.[137] For this chapter, which analyses the role of law in the development of the electricity sector, the legal measure to promote electricity from renewable sources is most relevant. Also, the overall topic of this thesis, a legal framework for smart electricity systems, relates to the objectives of increasing the share of RES. The introduction of this thesis presented SES as a novel way of physically integrating RES and distributing the related costs among the system users.[138] The goal to increase the share of electricity produced from RES has been gradually fostered from non-binding legislation, to indicative targets, to binding targets for the member states, and now most recently, a EU-wide target of RES share in gross final consumption. To reach those targets of RES shares the main regulatory tools are support schemes and priority access for electricity produced from renewable sources. The following subsections outline the development of the legal framework aiming to establish a low-carbon based electricity sector. This leads then to the final substantial section of this chapter (section 4), which identifies new developments as a result of incentivising RES.

3.2.1 Creating a Low-Carbon Electricity Sector

The overall objective on EU level to create a low-carbon electricity sector developed steadily and is justified by the following two major underlying concerns: firstly, reducing GHG emissions and fostering subsequent environmental benefits, and secondly, ensuring security of supply by increasing independence from fossil fuel markets and thereby tackling the challenges of unpredictable energy prices and possible geopolitical changes. Even though many regulatory efforts to combat climate change have been initiated dating back to 1988,[139] the beginning of the promotion of RES on a European

134. Directive 2012/27/EU on Energy Efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC [2012] OJ L315/1. In the following Directive 2012/27/EU.
135. Directive 2009/31/EC on the Geological Storage of Carbon Dioxide and amending Council Directive 85/337/EEC, European Parliament and Council Directives 2000/60/EC, 2001/80/EC, 2004/35/EC, 2006/12/EC, 2008/1/EC and Regulation (EC) No 1013/2006 [2009] OJ L140/114. In the following Directive 2009/31/EC.
136. Directive 2009/28/EC on the Promotion of the Use of Energy from Renewable Sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC [2009] OJ L140/16. In the following Directive 2009/28/EC.
137. European Environment Agency, Greenhouse Gas – Data Viewer.
138. See Introduction - Unlocking Flexibility with Law, section 1 “Introduction”.
139. Commission of the EC, Communication from the Commission to the Council on the Greenhouse Effect and the Community, establishing the Commission Work Programme concerning the Evaluation of Policy Evaluation to deal with the Greenhouse Effect and a Draft Resolution on the Greenhouse Effect and the Community COM(1988)656, 16 November 1988. For a detailed discussion of EU legislation on climate change mitigation see Marjan Peeters and Kurt Deketelaere (eds) *EU Climate Change Policy: The Challenge of New Regulatory Initiatives* (Edward Elgar Publishing 2006).

level is often referred to the White Paper of the Commission, published 1997, on renewable sources of energy, which recognised the need to develop a comprehensive strategy for RES for a number of reasons.[140] The priority measures with regard to increasing the share of RES are identified as firstly, providing fair access for RES to the electricity market, secondly, fiscal and finance measures for supporting RES, thirdly, new bioenergy initiative for transport, heat, and electricity, and fourthly, improving building regulations.[141] Those measures have a significant impact on the national electricity systems in terms of fuel and technology choice, illustrating the linkage between the organisation and the technology component of the electricity sector. The following section outlines the development of the legal framework implementing the objective of a low-carbon electricity sector in more detail.

3.2.2 Promoting Electricity from Renewable Energy Sources

The widely accepted goal to combat climate change and the significant potential of the electricity sector in reducing GHG emissions led to the adoption of the first Directive specifically addressing the promotion of RES on European level (hereafter: Directive 2001/77).[142] The discussions preceding the adoption of Directive 2001/77 among the European institutions exemplified the various interests involved in the sector. Additionally, discussions between the European and the national level, and also among member states with varying potential to generate electricity from renewable sources complicated the legislative process. The main issue at stake was the character of RES targets, which could either be indicative or binding.[143] Reviewing the development of Directive 2001/77 it is often referred to as *"compromise of many of those issues"*.[144] Still, the Directive paved the way for integrating and promoting RES on a European level, setting targets and acknowledging support schemes for RES with regard to competition concerns. Directive 2001/77 set four main milestones for promoting the sources of RES. Firstly, it defined RES.[145] Secondly, it set individual targets for each member state with an indicative percentage of RES contribution.[146] Those targets were set in consistency with the Community wide target of 22% of electricity produced from renewable energy

140. Commission of the EC, Communication from the Commission - Energy for the Future: Renewable Sources of Energy. White Paper for a Community Strategy and Action Plan, COM(1997)599 final 26 November 1997, 7.
141. Commission of the EC, Communication from the Commission - Energy for the Future: Renewable Sources of Energy. White Paper for a Community Strategy and Action Plan, COM(1997)599 final 26 November 1997, 14 – 18.
142. Directive 2001/77/EC on the Promotion of Electricity Produced from Renewable Energy Sources in the Internal Electricity Market [2001] OJ L283/27. In the following Directive 2001/77/EC.
143. The discussion also addressed the definition of the term 'renewable' and whether large hydropower plants should be included.
144. Ian Rowlands, 'The European Directive on Renewable Electricity: Conflicts and Compromises' (2005) 33 Energy Policy 965-974, 972.
145. Art. 2(a) defined: *"'renewable energy sources'" shall mean renewable non-fossil energy sources (wind, solar, geothermal, wave, tidal, hydropower, biomass, landfill gas, sewage treatment plant gas and biogases)"*.
146. Annex Directive 2001/77/EC.

sources by 2010.[147] Yet, the actual legal strength of those targets has been doubted. Despite the rather weak character of the indicative targets, the member states were still obliged to publish a report containing an analysis of success in meeting the national indicative target.[148] Member states were thus at least obliged to evaluate on the options for meeting their target. Thirdly, Directive 2001/77 provided the option for support schemes for RES.[149] And fourthly, the Directive provided for guaranteed access to the grid for RES.[150]

The first assessment by the EU Commission regarding the performance of member states to meet the indicative targets was carried out in 2004 and published in a Communication.[151] The main finding revealed that the situation varied considerably between the member states. The fact that only a few member states were able to comply suggested that the approach was too challenging and would lead to undesired unequal developments among the member states.[152] As a response the EU Commission not only deepened the existing reasons to strengthen RES, but also widened the drivers to decrease dependency on imports of fossil fuels from third states and thereby reacted to possible geopolitical uncertainties. The EU Commission stated that

> *"the EU and the rest of the world are at the crossroads concerning the future of energy. Climate change, increasing dependence on oil and fossil fuels, growing imports, and rising energy costs are making our societies vulnerable. These challenges call for a comprehensive and ambitious response".*[153]

The "Renewable Energy Roadmap 2007" addressed those challenges and it was decided to introduce binding targets; the 20-20-20 strategy was established which was promoted by the EU Commission as follows:

> *"By 2020, the EU aims to reduce its greenhouse gas emissions by at least 20%, increase the share of renewable energy to at least 20% of consumption, and achieve energy savings of 20% or more. All EU countries must also achieve a 10% share of renewable*

147. Art. 3(4) Directive 2001/77/EC.
148. Art. 3(3) Directive 2001/77/EC.
149. Art. 4 Directive 2001/77/EC.
150. Art. 7 Directive 2001/77/EC.
151. European Commission, 'Communication of the Commission to the Council and the European Parliament, the share of renewable energy in the EU Commission Report in accordance with Article 3 of Directive 2001/77/EC, evaluation of the effect of legislative instruments and other Community policies on the development of the contribution of renewable energy sources in the EU and proposals for concrete actions', COM(2004)366.
152. Nicole Ahner, 'The New Renewables Framework for Europe: Implementing Directive 2009/28/EC', in Martha Roggenkamp and Ulf Hammer *European Energy Law Report, VIII* (Intersentia 2011) 93-116, 95.
153. European Commission, Renewable Energy Road Map Renewable Energies in the 21st Century: Building a more Sustainable Future COM(2006)848, 10 January 2007, 3.

energy in their transport sector. Through the attainment of these targets, the EU can help combat climate change and air pollution, decrease its dependence on foreign fossil fuels, and keep energy affordable for consumers and businesses."[154]

The formulation of this policy led to the adoption of a new directive which incorporated two main changes to the existing legal framework, namely binding targets of RES in gross final consumption for member states and different possibilities for member states to cooperate in order to achieve their targets. The following sections outlines these changes and current developments of the legal framework promoting the use of RES.

3.2.3 20/20/20 Strategy and Beyond

The challenges to meet indicative targets of a particular share in RES were acknowledged and a new Directive was adopted in 2009 (hereafter: Directive 2009/28).[155] As mentioned, the Directive marked a change of the regulatory approach towards the development of RES by setting binding national targets and the option for cooperation among member states. Directive 2009/28 set binding targets by obliging member states to ensure that *"the share of energy from renewable sources in gross final consumption of energy in 2020 is at least its national overall target for the share of energy from renewable sources in that year* […]".[156] These targets ranged from 10% (Malta) to 49% (Sweden). Member states were further obliged to adopt a national renewable energy action plan (NREAP), which needed to be submitted to the EU Commission.[157] According to the initial problem of an unequal development among member states, the Directive took into account potential differences between member states in the ability to produce electricity from RES and reiterated the usage of support schemes, and introduced the possibility of cooperation mechanisms.

Directive 2009/28 defined support schemes broadly as

> *"any instrument, scheme or mechanism applied by a Member State or a group of Member States, that promotes the use of energy from renewable sources by reducing the cost of that energy, increasing the price at which it can be sold, or increasing, by means of a renewable energy obligation or otherwise, the volume of such energy purchased with the main aim to maintain investor confidence".*[158]

154. European Commission, '2020 Energy Strategy'.
155. Directive 2009/28/EC on the Promotion of the Use of Energy from Renewable Sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC [2009] OJ L140/16. In the following Directive 2009/28/EC.
156. Art. 3(1) Directive 2009/28/EC, the targets for the individual member states are established in table A of Annex I of that Directive.
157. Art. 4 Directive 2009/28/EC.
158. Art. 2(k) and recital 25 Directive 2009/28/EC.

Subsequently, throughout the member states several mechanisms of support schemes were implemented. The objective of support schemes in the first place is the assumption that RES technologies are commercially not mature yet and need financial support in order to sustain in the market.[159] Regulatory financial support schemes can have various forms; the two main types are price-driven and quantity-driven schemes. Price-driven strategies constitute financial support for the generator on basis of a subsidy per generated unit. Most popular is the system of a Feed-in-Tariff (FiT) under which the generator receives a fixed amount for a certain period of time, hence the FiT provides a strong support due to a high degree of predictability. In contrast, quantity-driven schemes quotas are set and the goal is reached through bidding schemes or tradable certificates.[160] The Directive leaves discretion to the member states in defining the potential beneficiaries of support schemes by stating: *"Member States shall clearly define any technical specifications which must be met by renewable energy equipment and systems in order to benefit from support schemes"*.[161] The Directive further pushed RES by establishing that member states *"shall provide for either priority access or guaranteed access to the grid-system of electricity produced from renewable energy sources"*.[162] This provided an additional measure of certainty for investors in RES generation by providing RES precedence in access.

Moreover, Directive 2009/28 provided the option for member states to make use of cooperation mechanisms to meet the binding target of RES share. The following four cooperation mechanisms are established:[163] firstly, the statistical transfer mechanism provides member states the option to trade a generated surplus of RES to another member state struggling to comply with its target.[164] Secondly, the joint project mechanism establishes *"two or more Member States may cooperate on all types of joint projects relating to the production of electricity, heating or cooling from renewable energy sources. That cooperation may involve private operators"*.[165] Thirdly, the mechanism of joint support schemes allows to harmonise support schemes in order to meet the national target.[166] Fourthly, member states have the possibility to engage in joint projects with third countries.[167] However, according to the NREAP the vast majority of the member

159. Stephanie Ropenus Henrik Klinge Jacobsen, Sascha Schröder, 'Network Regulation and Support Schemes – How Policy Interactions affect the Integration of Distributed Generation' (2011) 36(7) Renewable Energy 1949-1956, 1952.
160. Hans Auer, Gustav Resch, Reinhard Haas, Anne Held and Mario Ragwitz, 'Regulatory Instruments to deliver the Full Potential of Renewable Energy Sources Efficiently' (2009) 3(2) European Review of Energy Markets, 1-34, 5.
161. Art. 13(2) Directive 2009/28/EC.
162. Art. 16 (2b) Directive 2009/28/EC.
163. Corinna Klessmann, Patrick Lamers, Mario Ragwitz, and Gustav Resch, 'Design Options for Cooperation Mechanisms under the New European Renewable Energy Directive' (2010) 38(8) Energy Policy 4679-4689, 4681.
164. Art. 6 Directive 2009/28/EC.
165. Art. 7 Directive 2009/28/EC.
166. Art. 11 Directive 2009/28/EC.
167. Art. 9 Directive 2009/28/EC.

states are not planning to make use of the cooperation mechanisms. Member states rather seem to increase the usage solely on the basis of their national target but the cooperation mechanisms do not constitute an additional incentive.

The effort to combat climate change and to reduce fossil fuel dependency on third countries by promoting RES has been strengthened, but a large degree of discretion is left to the member states. This still causes unequal developments and continuously challenges the integrity of the internal market by raising questions with regard to a level playing field for actors in the electricity system. This issue became evident in *Ålands Vindkraft AB vs Energimyndigheten* were the ECJ ruled that governments can restrict the access to their national support RES scheme for electricity generated outside their territory, even though in this case the production plant was connected to the national grid.[168] Reassessing the developments in the promotion of RES, the EU Commission stated in a Communication on the policy framework for climate and energy in the period from 2020 to 2030 that the following RES targets will be set on EU level instead of assigning individual targets for each member state.[169] This announcement materialised in a revised directive on the promotion of RES which was published in the Official Journal of the EU in December 2018 (hereafter Directive 2018/2001).[170]

3.2.4 The Way Forward: Including Decentralisation in EU RES Legislation

At the time of writing this thesis, the final adopted text of Directive 2018/2001 has only been published for a couple of months, therefore, an exhaustive analysis of the text and its impact is not present at this point. Yet, some points are worth mentioning as those also relate to the following section 4 the "electricity sector in flux" and also to the further subject of this thesis. Directive 2018/2001 is then further discussed against the findings of this thesis in chapter 4 of this thesis.

The final text of Directive 2018/2001 indeed delivers on the announcement of the EU Commission made in 2014 by setting a binding Union target for the overall share of energy from renewable sources in the Union's gross final consumption of energy in 2030. Directive 2018/2001 states that *"Member States shall collectively ensure that the share of energy from renewable sources in the Union's gross final consumption of energy*

168. C-573/12 *Ålands Vindkraft AB v Energimyndigheten*. Marek Szydlo, 'How to Reconcile National Support for Renewable Energy with Internal Market Obligations? The Task for the EU Legislature after Ålands Vindkraft and Essent' (2015) 52(2) Common Market Law Review 489-510.
169. European Commission, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions A Policy Framework for Climate and Energy in the Period from 2020 to 2030 COM(2014)15, 22 January 2014, 6. The RES Directive 2018/2001 is also discussed in chapter 4 of this thesis.
170. Directive 2018/2001 on the Promotion of the Use of Energy from Renewable Sources (recast) [2018] OJ L328/82.

in 2030 is at least 32%."[171] Additionally however, member states need to fulfil a baseline in gross final consumption of RES as of 2021.[172] Another important change is the abolishment of priority access for RES to the grid which aims at bringing RES generation in the market. Directive 2018/2001 also introduces completely new provisions which aim at capturing developments often summarised as "decentralisation of the electricity sector". Decentralisation entails that it is not only the source which changes with the promotion of RES, but potentially also the organisational structures of RES generation. RES enable also small-scale generation of electricity which is closely located to the points of consumption. In order to reap the potential of decentral, small-scale RES generation, national legal frameworks often implement subsidy schemes which incentivise residential customers to install, for example, solar panels on their roofs. Electricity is thus generated behind the metering point of the consuming unit and creates a phenomenon which is often referred to as "prosumer", a term constructed from the term "producer" and "consumer". This phenomenon is further outlined in the following section. At this point it is relevant to mention that the decentralisation and subsequent new organisational forms of generation and consumption and combinations thereof have been incorporated in Directive 2018/2001. This includes for example the definition of the term "renewables self-consumer" meaning

> *"a final customer operating within its premises located within confined boundaries or, where permitted by a Member State, within other premises, who generates renewable electricity for its own consumption, and who may store or sell self-generated renewable electricity, provided that, for a non-household renewables self-consumer, those activities do not constitute its primary commercial or professional activity".*[173]

Article 21 of Directive 2018/2001 further outlines the legal framework applicable to "renewable self-consumers" (RSC), which requires member states to establish an *"enabling framework to promote and facilitate the development of renewables self-consumption* […]".[174] Relevant to mention is that RSC are not restricted to generate for their own consumption, but are also entitled to engage in what is defined as "peer-to-peer trading arrangements"[175]. These are defined as follows:

> *"'peer-to-peer trading' of renewable energy means the sale of renewable energy between market participants by means of a contract with pre-determined conditions*

171. Art. 3(1) Directive 2018/2001/EU.
172. Art. 3(4) and Part A Annex I Directive 2018/2001/EU.
173. Art. 2(14) Directive 2018/2001/EU.
174. Art. 21(6) Directive 2018/2001/EU.
175. Art. 21(2a) Directive 2018/2001/EU.

governing the automated execution and settlement of the transaction, either directly between market participants or indirectly through a certified third-party market participant, such as an aggregator. The right to conduct peer-to-peer trading shall be without prejudice to the rights and obligations of the parties involved as final customers, producers, suppliers or aggregators"[176]

The entitlement of RSC to engage in peer-to-peer trading enables them to extend their current role from being consumers in the market to actively trading entities. Even though their commercial activity must not become their primary business activity, their role as merely passively consuming unit potentially changes with these provisions. Directive 2018/2001 also includes provisions on jointly acting RSC and renewable energy communities.[177] It is too early to assess how these newly introduced concepts prove their existence and how member states will implement these concepts in their national legislations. So far it can only be noted that this is a first attempt of explicitly including the decentralisation of the electricity sector in the EU legal framework. The following section further outlines the decentralisation of the electricity sector and explains decentral generation and the phenomenon of prosumption.

Similar to the liberalisation process, climate change mitigation by means of reducing GHG emissions and reducing fossil fuel dependency in the electricity sector has been shaping a part of the electricity sector. Mainly, the legal framework influences the choice of energy sources of member states and requires mechanisms to incentivise a specific technological development. Both developments show that the organisational component of the electricity sector can have a considerable impact on the technological component of the system. *Vice versa*, liberalisation and the efforts to increase RES jointly enabled new technological developments requiring new forms of organisation and coordination in the electricity sector. As outlined in this section, partly, these developments are now reflected in EU legislation on the promotion of RES. The following section introduces "the electricity sector in flux" which further outlines developments of the decentralisation of the electricity sector.

4. REVOLUTION 2.0 – THE ELECTRICITY SECTOR IN FLUX[178]

The previous section described how law has been influencing the organisational and the technology component of the electricity sector and, *vice versa*, how

176. Art. 2(18) Directive 2018/2001/EU.
177. Art. 2(15) and 2(16) Directive 2018/2001/EU.
178. The electricity sector is always "in flux" regarding technical and organisational developments. The title of this section aims at capturing a variety of ongoing developments in the electricity sector, which are sometimes also referred to as

technological developments require the organisational component to respond. The efforts of liberalisation and RES significantly shaped and are still shaping the setting of the electricity sector, which in turn unleashes various technical and organisational developments. The preceding section on the revised RES directive briefly mentioned the development of decentralisation of the electricity sector due to various small-scale RES generation technologies. In contrast to an electricity sector with large generation installations which are remotely located from the points of final consumption, decentralisation entails an increasing amount of small-scale generation on basis of RES which is located closer to the point of final consumption. This development is taking place at the low-voltage distribution grid level. The distribution system was originally designed to forward the electricity which has been generated in large remote generation installations and transported over long distances via the transmission system to the final consumers, mostly households and small enterprises which are connected to the distribution grid. This section describes three developments which are emerging at distribution system level, decentral generation (DG), "prosumption", and the need for demand flexibility at distribution system level. Decentralised generation is generation which is directly connected to the distribution grid and thereby located closer to the loads that it serves. Prosumption describes the phenomenon of consumers who start generating electricity primarily for their own needs. Demand flexibility is the ability of the demand-side to follow generation. These developments are not new as the very first generation installations were decentral and, for example, factories and farmers have been generating electricity for their own needs. However, the setting of the electricity sector has changed since then which make the reoccurrence of DG, prosumption, and demand flexibility old phenomena in a new context. The preceding section on the revised Directive 2018/2001 on the promotion of RES shows that the legislator invents new definitions in order to incorporate these developments. Again, this exemplifies the reciprocal relationship between technology and organisation in the electricity sector. Technical developments require legal responses, and novel legal provisions create space or possibly hinder technical developments.

4.1 Decentral Generation

In the last decades market liberalisation and the technological sophistication of renewable energy generators jointly steered the development of decentral generation.[179] Liberalisation opened the market for competitive generation and

"decentralisation". The heading "electricity sector in flux" is continuously deployed in the following chapters of this thesis in order to refer to these developments.

179. Decentral generation is sometimes also referred to as 'distributed generation'. In this chapter both terms are used interchangeably.

required system operators with the duty to connect generators. Additionally, in contrast to electricity generated from fossil fuels or nuclear sources, RES technologies enabled small scale generation of electricity. Subsidy schemes and simplified administrative procedures further incentivse this development aiming to support the deployment of RES technologies and subsequently increase the share of RES. Together, this enabled the emergence of an increasing number of small-scale producers who connect their generation installation to the distribution grid. This is referred to as "decentral generation".

Decentral generation is often referred to as one of the necessary means to achieve targets in renewable electricity generation and even broader, support to the energy transition by making it more acceptable throughout society.

> *"Due to its decentralized nature and low environmental impact decentralized generation has the potential to foster the achievement of the EU energy policy objectives* […] *decentralized generation may also, indirectly, be the chosen solution in response to apparent social and environmental opposition to the construction of large-size power plants and higher-capacity transmission infrastructures".*[180]

Acknowledging the potential of decentral generation for an increase in RES, Directive 2018/2001 still entails the provision of its predecessor and not only suggests but requires member states to ensure that *"simplified and less burdensome authorisation procedures, including a simple-notification procedure, are established for decentralised devices, and for producing and storing energy from renewable sources."*[181] This is even stronger reiterated in the electricity market Directive 2009/72 in relation to authorisation procedures for new capacity stating that *"Member States shall ensure that specific authorisation procedures exist for small decentralised and/or distributed generation, which take into account their limited size and potential impact."*[182] The idea behind these provisions is to reduce the administrative burden for persons seeking to invest in DG, and thereby providing another measure for promoting RES.

EU legislation does not contain a specified definition of DG in terms of size of the generation installation, but broadly defines it as *"generation plants connected to the distribution system"*.[183] In contrast to generation connected to the transmission system, decentral generation is located closer to the loads, the final points of consumption,

180. Helder Lopes Ferreira Anca Costescu, Angelo L'Abbate, Philip Minnebo, Ginaluca Fulli, 'Distributed Generation and Distributed Market Diversity in Europe' (2011) 39(9) Energy Policy 5561-5571, 5561.
181. Art. 15(1d) Directive 2018/2001/EU
182. Art. 7(3) Directive 2009/72/EC.
183. Art. 2(31) Directive 2009/72/EC.

which bears the advantage of lower electricity losses due to the needless transport over long distances. This is also recognised by the electricity market Directive 2009/72 which links decentral generation to the overall goal of efficient grid expansion.

> *"When planning the development of the distribution network, energy efficiency/ demand-side management measures or distributed generation that might supplant the need to upgrade or replace electricity capacity shall be considered by the distribution system operator".*[184]

As legislation does not define the size of installations which account for DG, the concept includes various scales of generation. Those could be, for example, solar panels on houses or dwellings or other buildings, single wind turbines providing electricity for neighbourhoods or farmers, but also larger generation which is connected to the distribution grid.

Apart from the advantages for energy efficiency (lowering transmission losses) and RES targets, increasing amounts of decentralised generation also pose significant challenges to the technical component and the organisational setting of the electricity sector.[185] The main challenges can be categorised in the following two intertwined problems: technical problems which are related to a lack of grid capacity and maintaining grid integrity at distribution grid level and organisational problems which are related to lacking investment and competences of the DSOs.[186] The problems are related. The technical problems caused by variable RES DG are grid capacity constraints which require grid balancing and congestion management at distribution system level. The organisational setting of the electricity sector, however, does not foresee these competences for the DSO.[187] Central in the discussion how the electricity system can cope with this challenge is the degree of resilience of the electricity system. The term resilience is used in various disciplines, the following definition describes the term in the context of energy systems:

184. Art. 25(7) Directive 2009/72/EC.
185. Robert Passey, Ted Spooner, Iain MacGill, Muriel Watt, Katerina Syngellakis, 'The Potential Impacts of Grid-connected Distributed Generation and how to address them: A review of Technical and Non-technical Factors' (2011) 39 Energy Policy 6280-6290.
186. Rafael Cossent, Tomás, Pablo Frías, 'Towards a Future with Large Penetration of Distributed Generation: Is the Current Regulation of Electricity Distribution Ready? Regulatory Recommendations under a European Perspective' (2009) 37 Energy Policy1145-1155 and Jeroen de Joode, Jaap Janse, Adriaan van der Welle, Martin Scheepers, 'Increasing Penetration of Renewable and Distributed Electricity Generation and the Need for different Network Regulation', (2009) 37 Energy Policy 2907-2915.
187. Niels Blaauwbroek, Dirk Kuiken, Phuong Nguyen, Hans Vedder, Martha Roggenkamp, and Han Slootweg 'Distribution Network Monitoring: Interaction between EU Legal Conditions and State Estimation Accuracy' (2018) 115 Energy Policy 78–87, 78.

> *"The resilience encapsulates how such systems are able to respond to disruptive challenges. It is a measure of adaptive capacity and ability to learn how to cope and adjust. In an energy system context this approach should be envisaged as a process of co-evolution where actors and technologies interact within a system to minimise vulnerabilities and maximise opportunities."*[188]

This general description of resilience captures the interrelation between the technology component and the organisational component in the electricity sector. Essentially, resilience of a system (the electricity system) can only be guaranteed if the interplay between technology and organisation is ensured and coordinated. The following section outlines a related, but yet different development as conjunction between technology and organisation, namely prosumption.

4.2 Prosumption

While decentral generation entails small-scale installations, which are exclusively connected for generation purposes, prosumption is a more intricate phenomenon as it includes generation, but at the same time consumption within one installation. The term prosumption was already briefly mentioned in the section on the most recently revised EU RES Directive 2018/2001 (section 3.2.4) in relation to the new definition of what is called "renewable self-consumer". The section argued that with this new definition Directive 2018/2001 aims at capturing the development of prosumption in the electricity sector. This section further outlines prosumption in general and then identifies questions regarding the legal integration of prosumption, or prosumers, in the electricity sector.

Section 3.2.4 introduced the term prosumption as being constructed from the two words production and consumption.[189] In the electricity sector, prosumption describes persons connected to the grid, who generate electricity primarily for their own use behind the meter on their premises. This renders them at least partly self-sufficient for electricity supply. Yet, as prosumers can only partly cover their demand, they also remain dependent on electricity supply by a supply company.[190] Prosumption exists on various scales including larger industrial units, but increasingly also small customers who have been so far residential, household, consumers.[191] This development is also further

188. Geoff O'Brien and Alex Hope, 'Localism and Energy: Negotiating Approaches to Embedding Resilience in Energy Systems' (2010) 38 Energy Policy 7550-7558, 7050.
189. The term has been established by Alvin Toffler 1980. Toffler envisaged that the traditional line between production and consumption will become blurry. He did not necessarily relate this term to a specific industry. See for more information Alvin Toffler, *The Third Wave* (Bantam Books, 1980).
190. Rajab Khalilpour and Anthony Vassalo, 'Leaving the Grid: An Ambition or a Real Choice?' (2015) 82 Energy Policy 207-221.
191. Commission of the EU, 'Study on "Residential Prosumers" in the European Energy Union' (2 May 2017).

facilitated by specific legislation enabling prosumers and establishing remuneration schemes for RES.[192] The extent to which prosumers remain dependent on supply companies is determined by their installed generation capacity, the availability of the source of energy used for electricity generation, and electricity storage possibilities as for example electric vehicles, which provides flexibility for off-peak production periods. However, the latter one, storage facilities, are currently implemented only to a limited extent. Expectedly though, their value in application to provide for flexibility in demand, will increase in the near future. The value of flexibility and how it can be incorporated and incentivised by the legal framework of the electricity sector is subject to the following chapters of this thesis. For now, this section focuses on the phenomenon of prosumers, and more specifically residential prosumers, in the electricity sector, that are residential consumers who engage in electricity production by installing small-scale generation installations on their premises behind the metering point.

Additionally, to producing and consuming for own needs, prosumers might generate surplus electricity, that is electricity which exceeds the own use of the prosumer, or more specifically, times of generation do not match times of consumption. Considering that variability of RES and the average day consumption pattern, of for example households, do not necessarily correspond, the generation of significant amounts of surplus electricity is even very likely. Prosumers thus not only generate and consume electricity for their own needs and thereby change the conventional demand pattern, but also generate surplus electricity which is fed-back into the grid system. The surplus electricity causes technical challenges as electricity flows in both directions (bidirectional electricity flows) and demand and generation are becoming less predictable. Inevitably, this makes it more difficult to operate the grid and maintain the system in balance. Additionally, the generation of surplus electricity also causes challenges to the organisational setting. Physically the electricity flows back into the grid, however, from a legal perspective this poses the question whether this implies that prosumers account as a generator or even as a supplier, or whether the legal framework needs to develop new approaches for this development. Assessing the question how prosumers could fit in the current legal framework, it is relevant to consider the definitions of producer and consumer. Directive 2009/72 simply defines that *"'producer' means a natural or legal person generating electricity"*.[193] The broad character of the definition implements the aim of establishing a competitive market for electricity generation, so that no one is excluded of the electricity

192. Matthias Lang, 'Prosumer Legislation in Germany', Lea Diestelmeier and Dirk Kuiken, 'Legal Framework for Prosumers in the Netherlands', and Catherine Banet, 'Prosumer Legislation in Norway: A First Step for Empowering Small Energy Consumers' all in Martha Roggenkamp and Catherine Banet (eds) *European Energy Law Report XII* (Intersentia Energy & Law Series 2018).
193. Art. 2(2) Directive 2009/72/EC.

generation business in the first place. The definition allows that prosumers account for being electricity producers. Less straight-forward is the answer to the question whether the prosumer could also be considered as a supplier. The term supplier is not defined by the Directive 2009/72 but *"'supply' means the sale, including resale, of electricity to customers"*.[194] Assuming that the supplier is then a person selling or reselling electricity inevitability leads to the question to whom the prosumer sells the surplus electricity. Apart from those definitions in EU legislation, national legislation may provide more specified provisions on becoming a producer or supplier. Often, this includes a licensing regime and the condition to comply with several standards regarding technical expertise and financial security. Therefore, even though the definitions of generator and supplier in EU legislation appear to allow for the inclusion of electricity prosumers, more specific conditions are likely to be applicable under national legislation. Directive 2009/72 defines household customers as "[…] *a customer purchasing electricity for his own household consumption, excluding commercial or professional activities"*.[195] This customer group is subject to a specific protection regime which is elaborated in article 3 of Directive 2009/72. The protection measures for small customers (household customers and small enterprises) generally aim at providing specific protection to this group against the market powers of production and supply companies in the sector. While this protection framework does not preclude the development of prosumers, it would be necessary to assess to which extent those prosumers would still be in need of the measures specified in the protection framework or if they require different measures. This issue is assessed further below in this thesis in chapter 4. At this point it is relevant to conclude that EU electricity law sets the framework for a competitive internal electricity market by establishing broad definitions. However, regarding the emergence of the electricity prosumer raises the question whether legislation needs to accommodate and integrate this development more explicitly. The newly revised RES Directive 2018/2001 does so by including a definition on renewable self-consumers. It remains to be seen how this concept is implemented in subsequent national electricity sector legislation. The following section extends the concept of the prosumer beyond producing and consuming by introducing the idea of demand-flexibility.

4.3 Demand Flexibility

As explained in section 2.1 on the technology component of the electricity sector, the core task of operating the electricity system is balancing generation and consumption at any point in time. The core technical challenge that prosumers cause is increasing complexity in balancing generation and consumption due to bidirectional- and less

194. Art. 2(19) Directive 2009/72/EC.
195. Art. 2(10) Directive 2009/72/EC.

predictable electricity flows. In order to better manage these electricity flows and operate the electricity system, the technical solution needs to include precise information on electricity demand and generation of all system users. Currently, this information is not available at the distribution system level. Integrating increasing amounts of decentral generation and prosumption connected to the distribution grid however requires more accurately matching generation and consumption at distribution system level. This will necessarily include the demand-side of consumers too. This implies more flexible consumption of electricity, which is often referred to as demand flexibility.[196] Demand flexibility thus means that consumers adjust their consumption according to the availability and subsequent prices of generation. Regarding the variable character of RES, flexibility, and specifically demand flexibility, becomes of increasing value for harnessing RES.[197]

Not only does demand flexibility contribute to maintaining the technical integrity of the electricity system and enables the integration of variable RES, but it also includes an economic dimension.

> *"It will be essential to influence demand so that it is matching the production profile. In other words when the wind is blowing and electricity prices are getting lower, it will be an advantage if demand can be controlled more efficiently than today.* […] *As production at the same time will be decentralised, the consumer will get a double role – as a consumer and as a producer and both take and deliver electricity to the network – the term prosumer is sometimes used in this connection".*[198]

According to that, the concept of the electricity prosumer might possibly include a commercially-driven component beyond electricity production. This could be facilitated by shifting consumption to times when prices are rather low, shifting production (to the extent that it is possible with regard to RES) to times when prices are higher. A necessary precondition is transparent market information on prices which are close to real-time. The prosumer as an economic entity can be described as *"a consumer that becomes resonant with the energy market through systematic actions and reactions that aim to increase personal or collective benefits"*.[199] Even stronger, the concept of the electricity prosumer could be defined with this specific economic characteristic.

196. Goran Strbac, 'Demand Side Management: Benefits and Challenges' (2008) 36 Energy Policy 4419-4426.
197. Peter Lund, Juuso Lindgren, Jani Mikkola, and Jyri Salpakari, 'Review of Energy System Flexibility Measures to Enable High Levels of Variable Renewable Electricity' (2015) 45 Renewable Energy and Sustainable Energy Reviews 785-807, 788.
198. Anita Rønne, 'Smart Grids and Intelligent Energy Systems: A European Perspective' in Martha Roggenkamp, Lila Barrera-Hernández, Donald Zillman, and Iñigo del Guayo (eds) *Energy Networks and the Law: Innovative Solutions* (Oxford University Press 2012) 141-160, 145.
199. Iliana Shandorkova, Bernt Bremdal, Rainer Bacher, Stig Ottensen, and Andreas Nilsen, 'A Prosumer Oriented Energy Market. Developments and Future Outlooks for Smart Grid Oriented Energy Markets' (2012) (Improsume Publication

> *"This new emerging entity - a "prosumer"- is an economically motivated entity that: Consumes, produces, and stores electricity and energy in general, optimises the economic and to some extent the technological, environmental decisions regarding its energy utilisation, becomes actively involved in the value creating effort of an electricity or energy service of some kind".*[200]

This would imply that the prosumer is not merely striving for self-supply but is actively engaged in commercial activities. The development of the prosumer however not only depends on technical options, but also on the legal framework of the electricity sector. This section suggests that the variety of actors and their abilities to engage in the electricity market becomes more complex with developments which have here been summarised as "the electricity sector in flux".

4.4 Legal Response to "the Electricity Sector in Flux": *Clean Energy for All Europeans*

In November 2016, the EU Commission published a legislative package composed of various regulations and directives aiming to reform the EU electricity sector. The title of the legislative package *"Clean Energy for All Europeans"* (CEP) already suggests that the EU Commission is further pursuing the goal to facilitate the energy transition towards a *"clean"* – low-emission releasing – energy sector.[201] The package includes proposals reforming market structures, proposals reforming aims facilitating the shift to a low-carbon-based sector, and new measures.[202] One of the core issues addressed in this proposal is the integration of consumers in the electricity market, as the EU Commission promotes to *"putting consumers at the heart of the energy market"*.[203] In light of the discussed issues in the preceding sections, two proposals of the CEP are of special relevance for this thesis. The proposal for a recast electricity market directive (in the following referred to recast market directive 2019/--) and the directive on the

Series 2012), 36.

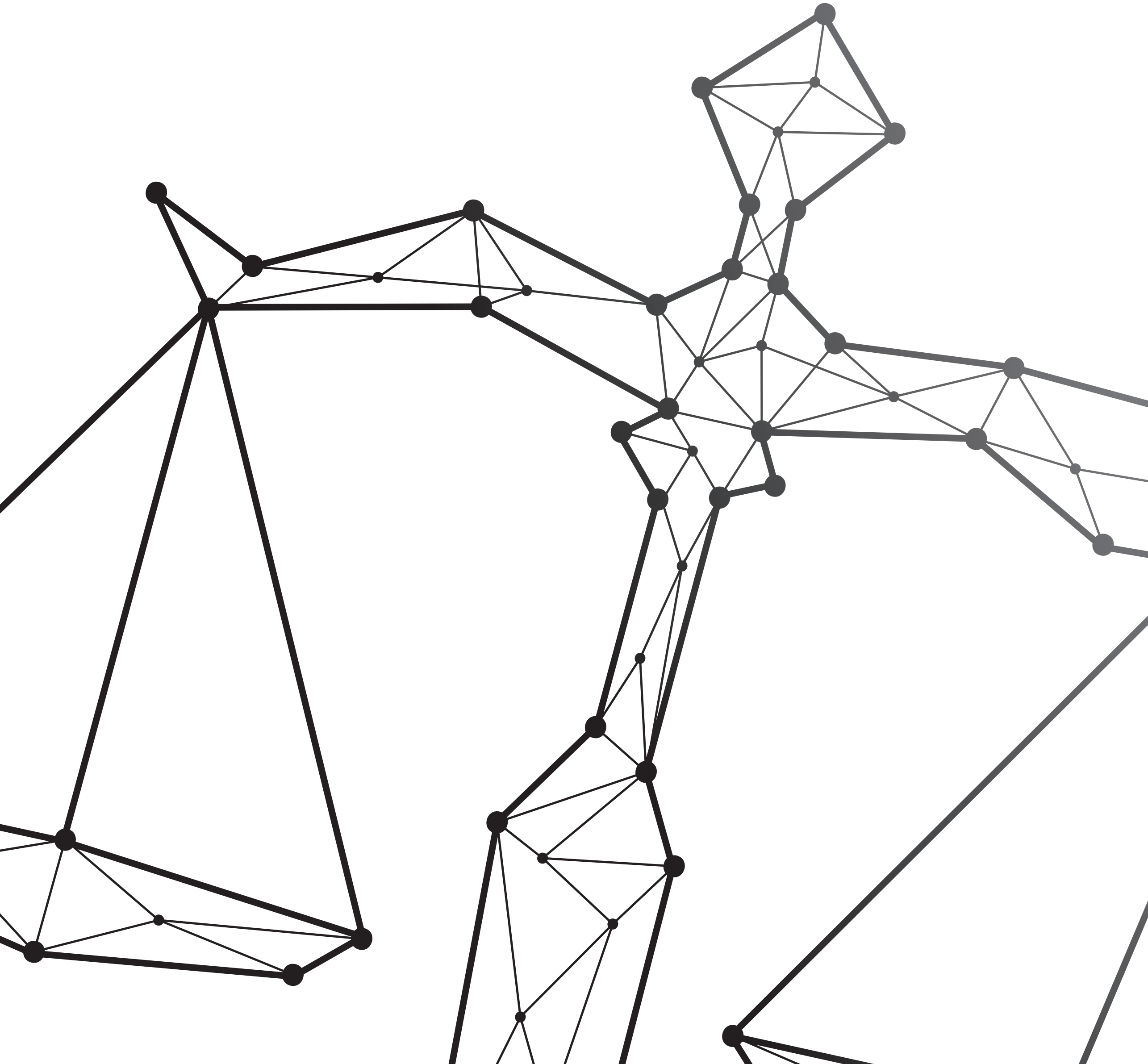
200. Iliana Shandorkova, Bernt Bremdal, Rainer Bacher, Stig Ottensen, and Andreas Nilsen, 'A Prosumer Oriented Energy Market. Developments and Future Outlooks for Smart Grid Oriented Energy Markets' (2012) (Improsume Publication Series 2012), 35.
201. EU Commission, 'Clean Energy Package for All Europeans' (30 November 2016).
202. The CEP includes the following documents which aim at reforming market structures: A recast directive amending the electricity market Directive 2009/72/EC, a recast regulation amending Regulation 714/2009 on conditions for access to the network for cross-border exchanges in electricity, and a recast regulation amending Regulation 713/2009 on ACER. The CEP includes the following documents which aim at reforming aims facilitating the shift to a low-carbon-based sector: a recast directive amending the RES Directive 2009/28/EC (the Directive has been adopted in 2018 and is now in force as Directive 2018/2001/EU, see above section 3.24 of this chapter), a recast directive amending the energy efficiency directive 2012/27/EU, and a recast directive amending Directive 2010/31/EU on the energy performance of buildings. Additionally, the package includes the following proposals for new legislations: a regulation on risk-preparedness and a proposed regulation on governance of the Energy Union.
203. Commission of the EU, 'Proposal for a Directive on Common Rules for the Internal Market in Electricity COM (2016) 864 final/2 (30.11.2016), p. 4.

promotion of energy from renewable sources, which has been adopted end 2018 and is in force as Directive 2018/2001 as discussed above in section 3.2.4. This chapter only mentions the proposal as a legal development as a response to "the electricity sector in flux". A more detailed analysis of the provisions, especially of the recast market directive, is carried out in chapter 4 of this thesis against the background of findings of this thesis regarding a legal framework for smart electricity systems.

5. CONCLUSION

This chapter described the term and development of the "electricity sector" and analysed the shaping role of law therein. The analysis reveals the following two overarching conclusions: firstly, the development of the electricity sector is a reciprocal process between the two components technology and organisation which entails law and economics. Secondly, the development of the EU electricity sector increasingly requires cooperation through Europeanisation of law for successfully achieving policy objectives such as liberalisation and facilitating a low-carbon based electricity sector for climate change mitigation and fuel independence objectives. Against this background, new developments, which have been summarised as "the electricity sector in flux" (DG, prosumption, and demand flexibility), require rethinking the organisation of the electricity sector and more specifically, the redesigning of the legal framework of the electricity sector. Emerging realities suggest that actors in the electricity sector do not necessarily fit anymore the established legal definitions and subsequent provisions, therefore, the legal framework is likely to become increasingly meaningless or even an obstacle for the further development of the electricity sector. The following chapter links the "electricity sector in flux" with smart electricity systems and identifies the need for a novel legal framework for SES.

Not only did this chapter provide the necessary background information regarding the historical development and the general setting of the electricity sector and the current legal framework, but it also established the cornerstone of this thesis for analysing the technical- and the organisational component of the electricity sector. More specifically, the focus of this thesis is the development of a legal framework for SES, entailing the technical component of SES and resulting new functionalities of the electricity system which need to be incorporated in the legal framework of the electricity sector.



CHAPTER 2:
THE RATIONALE OF SMART ELECTRICITY SYSTEMS AND THE SEARCH FOR A NOVEL LEGAL FRAMEWORK

1. INTRODUCTION

Deriving from the preceding chapter, the role of law is shaping in the development of the electricity sector. This becomes evident by the establishment of the internal energy market in the EU and RES promotion for the purpose of climate change mitigation and fuel independency from third states. Yet, the shift towards common EU policy goals and subsequent legislation does not necessarily imply a centralisation of tasks. On the contrary, tasks are divided among an increasing number of actors and stakeholders on different organisational levels, the EU, national, and local levels. Furthermore, the chapter argued that the policy objectives established at the organisational component of the electricity sector cause changes on the technology component, resulting in the "electricity sector in flux", which was characterised by decentral generation, "prosumption", and demand flexibility.[204] This chapter firstly links these developments with what is referred to as "smart electricity systems" and secondly, identifies the need for a novel legal framework for SES.

Linking the "electricity sector in flux" with the need to develop SES requires understanding of the policy objectives underlying the design and operation of the current electricity sector. The previous chapter outlined market liberalisation and RES promotion as explicit political policy choices which materialised in specific electricity sector legislation and resulting in "the electricity sector in flux". The chapter thereby outlined the current setting of the electricity sector. The focus of this present chapter is on more overarching policy objectives, namely ensuring an adequate, affordable, and sustainable electricity sector. The specific terminology of these objectives varies and may, for example, also be referred to as "security of supply – market - environment-triangle".[205] In the EU, these policy objectives are often described as facilitating a "competitive, sustainable, and secure" energy sector.[206] For the purpose of this chapter, the chosen terms are "adequacy, affordability, and sustainability". The three terms are explained in section 2.2 of this chapter. The composition of these policy objectives is sometimes referred to as "energy policy triangle" or even "energy policy trilemma", as ensuring the implementation often implies trade-offs among the objectives.[207] This places the design of energy

204. See chapter 1, section 4 "Revolution 2.0 – The Electricity System in Flux".
205. The World Energy Council refers to it as "energy security, energy equity, and environmental sustainability". World Energy Council, 'World Energy Trilemma Index 2018". For the purpose of this chapter, and also for this thesis, are the terms "adequacy, affordability, and sustainability". The three terms are explained in section 2.2 of this chapter.
206. Specific EU policy documents are mentioned in footnote 13.
207. Chapter 1 already indicated potential conflicting interests between the objective of establishing the internal market and the promotion of RES. See chapter 1, section 3.2.3 "20/20/20 Strategy and Beyond", more specifically, the issues at stake in the *Ålands Vindkraft AB vs Energimyndigheten* case. The complexity at stake between market- and environmental objectives is even increased with the objective to maintain reliability in electricity supply by adequate generation- and transport (transmission and distribution) capacity.

law in the middle of, at least partly, conflicting policy objectives.[208] Maintaining these policy objectives in the "electricity sector in flux" becomes even more difficult as the technical options and actors in the electricity sector multiply. This requires new forms of coordination and cost-distribution of electricity system usage. Smart electricity systems may be a potential solution to this problem.[209] This chapter thus explains the rationale of SES as reconciling the energy trilemma in the context of growing amounts of decentral generation, prosumption, and demand flexibility.

The overall research question of this thesis prescribes the need for developing a legal framework which enables and incentivises the integration of smart electricity systems. The success of this integration requires that SES become an integral part of the planning and operational process in the electricity sector. To this end, the legal framework not only needs to incentivise technical innovation, but also the emergence of new actors who deploy, operate, and engage with SES technologies. The specific design of a legal framework to this objective is not clear and potentially bears conflicts between existing and emerging goals and actors. This chapter illustrates that this difficulty is exacerbated by the fact that SES cannot be captured by a globally accepted definition of technologies and actors, but can rather be described along their objectives and functionalities for a near-future electricity sector which reconciles the above-mentioned policy objectives of an adequate, affordable, and sustainable electricity sector. While this chapter argues that this is a more useful and realistic way of understanding the idea and purpose of SES, this clearly also leaves more ambiguities. The resulting complexity for developing a legal framework for innovation in the electricity sector is illustrated in this chapter with a case study of the Netherlands. This case study concerns experimental legislation which allows for specified deviations from the current Dutch Electricity Act with the aim of investigating new organisational forms which accelerate the deployment of decentral RES in the electricity sector and enable efficient grid operation. This example does not in particular address the implementation of SES as such, but at least elements of SES. Moreover, this example can serve as a case study for understanding the dynamics between technological innovation and corresponding novel organisational forms which need to be codified in a legal framework. Based on results of this analysis, this chapter identifies why current attempts to develop a legal framework for SES remain limited in their results and thereby provides reason and need for further research on how to develop a legal framework which enables and incentivises SES.

208. Raphael Heffron, Darren McCauley, and Benjamin Sovacool, 'Resolving Society's Energy Trilemma through the Energy Justice Metric' (2015) 87 Energy Policy 168-176, 169.
209. Jeannie Oliver and Benjamin Sovacool, 'The Energy Trilemma and the Smart Grid: Implications Beyond the United States' (2017) 4(1) Asia & the Pacific Policy Studies 70-84, 74.

This chapter is structured as follows: after this introduction, section 2 identifies the main EU policy goals applicable to the electricity sector and thereby identifies what is often referred to as "energy policy trilemma". Section 3 delineates the rationale and the necessity of the electricity sector transformation, outlines the idea of SES on the basis of their main envisaged objectives and concludes by establishing the quest for a novel legal framework for SES. Section 4 then illustrates the complexity of technical innovation and the search for novel legislation by an example of experimental legislation designed for accelerating decentral generation on basis of RES. Section 5 concludes that the outcome of the development of a legal framework which incentivises SES strongly depends on the policy goals and actors that are considered in the design process. Attempts to develop legal frameworks for SES often remain limited in their findings and result in incremental knowledge generation as they often address singled-out technologies This provides reason and necessity for further research and further leads to chapter 3 which establishes theoretical groundwork for a legal framework for SES.

2. UNDER PRESSURE: GRID CAPACITY AND POLICY GOALS

Understanding SES and the subsequent need for a novel legal framework firstly requires understanding the background of the need for such innovation. To this end, this section firstly outlines the main technical requirement for electricity network planning and operation (technology component) and secondly, describes the main EU policy goals in the electricity sector (organisational component). Relating the two components in this way explains the limits of the current setting in realising all three policy goals, especially in the in the context of "the electricity sector in flux" which causes additional challenges for the technical- and the organisational component of the sector. Maintaining, or even realising, the three policy goals in the electricity sector is often identified as an unfeasible balancing act and the introduction of this chapter mentioned that this is often referred to as "energy policy trilemma". As grid capacity is limited, the policy goal of increasing the share of variable RES pressures the goals of maintaining the electricity system adequate and affordable. Explaining this relation between the technical component and the organisational component is necessary for further understanding SES which provides a novel approach for coordinating system usage and cost distribution among system users (section 3 of this chapter).

2.1 Technology Component: Load Forecasting

Due to the fact that grid capacity is limited, the design and operation of electricity systems is determined by the demand (the loads) that it serves. Determining the load is a complicated endeavour called "load forecasting". The calculation of the loads can be done according to various mathematical methods and on basis of a plethora of data. The method and the data are thus decisive for the outcome of electricity system planning and operation. This makes load forecasting a highly specific task and crucial for the design and operation of the electricity system. For the purpose of this chapter it is certainly not relevant to understand the calculations and methods of load forecasting; rather the aim of this section is to provide an idea of the complexity behind grid infrastructure planning and operation as grid capacity is limited. Finally, this provides further insights about the reason why SES have become such a popular and desirable idea in the electricity sector.

As grid capacity is limited and as it is a very costly endeavour for system operators to expand capacity, load forecasting needs to be as precise as possible in order to mitigate over- or underinvestment in grid infrastructure. Even though various methods which incorporate uncertainty components have been developed, the exact forecasting is impossible not at least by virtue of unforeseeable future developments.[210] Uncertainty increases with long-term planning and becomes more predictable with shorter time frames. Load forecasting must be done for a large variety of time frames, from decades to days, and hours. Thereby it fulfils several functions either for the day-to-day operation of the grid or for structural investment decisions. Hence, load forecasting *"is at the core of nearly all decisions made in energy markets"*.[211] For example, load forecasting is considered as the determining factor for planning upgrades of existing infrastructure or even for planning new infrastructure, which is done in a time frame of several years.[212] This is usually denoted by the literature as *"long-term load forecasting"*.[213] Mathematical models aim at coming as close as possible to realistic demands, not at least due to economic implications because already minor miscalculations might cause significant differences between expected and real loads.[214] Not only are the mathematical models based on assumptions, but also the data for the calculation is based on estimates to some extent. Especially for long-term load forecasts a range of factors must be considered

210. Jürgen Schlabbach and Karl-Heinz Rofalski, *Power System Engineering: Planning, Design and Operation of Power Systems and Equipment* (2[nd] edn Wiley-VHC Verlag, 2014), 11 and Eugene Feinberg and Dora Genethliou, 'Load Forecasting' in Joe Chow, Felix Wu, and James Momoh (eds) *Applied Mathematics for Restructured Electric Power Systems – Optimization, Control, and Computational Intelligence* (Springer 2005) 269-285, 272.
211. Heiko Hahn, Silja Meyer-Nieberg, and Stefan Pickl, 'Electric Load Forecasting Methods: Tools for Decision Making', (2009) 199(3) European Journal of Operational Research 902-907, 902.
212. Literature on electricity infrastructure planning time frames estimates that *"the planning horizon is up to 10 years in low-voltage systems and can exceed 20 years in high-voltage transmission systems"* Jürgen Schlabbach and Karl-Heinz Rofalski, *Power System Engineering: Planning, Design and Operation of Power Systems and Equipment* (2nd edn Wiley-VHC Verlag, 2014), 5.
213. Eugene Feinberg and Dora Genethliou, 'Load Forecasting' in Joe Chow, Felix Wu, and James Momoh (eds) *Applied Mathematics for Restructured Electric Power Systems – Optimization, Control, and Computational Intelligence* (Springer 2005) 269-285, 273.
214. Damitha Ranaweera, George Karady, and Richard Farmer, 'Economic Impact Analysis of Load Forecasting' (1997) 12(3) IEEE Transactions on Power Systems 1388-1392, 1388.

which are difficult to predict, such as for example various demographic and economic factors.[215] This complexity is even exacerbated in the context of the "electricity sector in flux" where increasing amounts of distributed variable generation and growing electrification, for example electricity vehicles, complicate load forecasting for all time frames (decades, days, hours). Next to long-term load forecasting this illustrates that day-to-day forecasting and intra-day balancing also become increasingly difficult. Here, it is not the investment in the grid infrastructure which is at stake, but the operation of the grid. It is not merely the demand which needs to be taken into consideration, but the increasing amount of distributed generation based on variable RES sources and possibly "prosumption" too.

In order to precisely determine the needed grid capacity and manage the day-to-day operation of the grid, load forecasting needs to consider an increasing number of factors which can hardly all be identified and incorporated in the planning process. Current load forecasting which takes the load to be served by the grid as main the determining factor does not seem to be a sufficiently feasible and realistic method anymore for grid capacity estimations in the context of distributed generation and prosumption, because a plethora of technologies and actors would need to be taken into consideration. Yet, designing, planning, and operating the electricity system remains crucial for ensuring reliable electricity supply. Further below, this chapter introduces SES as a technical solution to this problem. Prior to that, the next sections introduce the main EU policy goals to be realised in the electricity sector. This extends on chapter 1, which mainly described the influence of EU policy goals and subsequent legislation on the setting of the current electricity sector, by outlining policy objectives which need to be considered for the future design and operation of electricity systems. This also further illustrates the relation between the technical component and the organisational component which prescribes objectives that serve a larger need for society as a whole. The clash between both components is further elaborated at the end of section 2 and leads to the quest for technical and organisational innovation as introduced in section 3 of this chapter.

2.2 Organisational Component: The Triangle of EU Electricity Sector Policy Goals

Electricity infrastructure planning and operation does not only depend on technical requirements but also on overall policy goals and the designation of tasks to various actors in the sector.[216] Policy goals establish overall aims towards which the electricity

215. Heiko Hahn, Silja Meyer-Nieberg, and Stefan Pickl, 'Electric Load Forecasting Methods: Tools for Decision Making', (2009) 199(3) European Journal of Operational Research 902-907, 903.
216. Alexander Weber, Thorsten Beckers, Patrick Behr, Niels Bieschke, Stella Fehner, and Christian von Hirschhausen, 'Long-Term Power System Planning in the Context of Changing Policy Objectives – Conceptual Issues and Selected Evidence

sector should be directed. Those goals represent interests which are affected by the electricity sector in the economic, social, and environmental realms and thereby constitute generally accepted aims which serve society at large. This chapter sets out those policy goals for the following two main reasons: firstly, describing the main policy goals allows a better understanding of the current organisational setting of the electricity sector as the policy goals describe the rationale of the design of the legal framework. Secondly, understanding the policy goals and their interdependence also allows understanding the quest for technical innovation and more specifically the SES as a possible technical innovation for maintaining and realising the policy goals in the future. In the electricity sector, policy goals developed along the following three main overall concerns: adequacy, affordability, and sustainability.[217] As mentioned, the policy goals are interdependent and can hardly be seen in complete isolation, their implementation is therefore a complicated balancing act (a "trilemma"). This section does not add to the discussion of how to balance those goals, but describes their main rationales and illustrates their current implementation in the legal framework of the electricity sector. The focus in the following subsections is on the relation between the technical component (the electricity system), the organisational component (the existing policy goals), and the "electricity sector in flux" which expectedly requires reconciling both components via SES and a legal framework enabling and incentivising SES. Thereby this chapter, more specifically this section, contribute to explaining the rationale for SES.

2.2.1 Adequacy

The policy goal "adequacy" refers to the following two necessary conditions for a functioning electricity system: the need for adequate generation capacity and the need for adequate transportation (transmission and distribution) capacity to serve the loads or in other words to *"satisfy demand"*.[218] This section focuses on the latter issue, adequate transport capacity as this further relates to the functionality of SES to coordinate electricity system usage (section 3).[219] Adequacy of transmission and distribution infrastructure closely connects to the above outlined technical requirement of load-forecasting for any timeframe (from long-term planning to intra-day system

from Europe' (Smart Energy for Europe Platform, Workgroup for Infrastructure Policy, Berlin University of Technology 2013), 1.

217. Specific EU policy documents are mentioned in footnote 13.

218. Hamilcar Knops defines the term 'adequacy' for the electricity system as follows: *"[…] the ability of the electric system to supply the aggregate electrical demand and energy requirements of the customers at all times, taking into account scheduled and reasonably unscheduled outages of system elements"* Hamilcar Knops, *A Functional Legal Design for Reliable Electricity Supply – How Technology Affects Law* (Energy & Law Series 6 Intersentia 2008), 95.

219. For the issue of adequate generation adequacy in liberalised electricity sector see F. Wen F, Felix Wu F, Y. Ni, 'Generation Capacity Adequacy in the Competitive Electricity Market Environment', (2004) 26 International Journal of Electrical and Power Energy Systems 365-372.

operation). For each time-frame, the planning or the operation of electricity systems has to ensure adequate transport capacity, that means the ability of the of transmission and distribution system to supply demand at all times. Earlier noted in chapter 1, brown- or blackouts in Europe mainly occurred due to inadequate transportation networks and not due to shortcomings in generation capacity.[220] Since electricity infrastructure has been developed and built along the need for increasing electricity demand,[221] the goal to ensure adequate infrastructure has always been at the core of grid infrastructure development. With the increasing importance and dependence of the availability of electricity, adequacy developed more explicitly as a policy goal and is often also referred to as reliability of the electricity system.[222] This section outlines the representation of the policy goal adequacy in the EU legal framework of the electricity sector.

Before the liberalisation of the EU electricity sector, ensuring the policy goal of adequate infrastructure for the transmission and distribution of electricity was less complex, simply because fewer actors were involved in the planning and operation of the electricity system. Vertically integrated utilities were responsible to implement the target of sufficient generation, transmission, and distribution capacity; hence operation, planning, and coordination was not complicated by institutional obstacles and coordination needs. The liberalisation of the electricity sector changed this setting and subsequently influenced the planning and operation of the electricity system considerably.

> "[…] *in that paradigm* [liberalisation]*, it is for the market to determine, where, when, and how much investments must be done in terms of infrastructure. In that context, EU efforts were not directed at guaranteeing investment in infrastructure via governmental compulsory planning, but rather to open markets, break monopolies, unbundle integrated energy companies, and introduce third party access obligations".*[223]

One of the most severe and thus most discussed issues in this development concerns the question whether market mechanisms can ensure sufficient investment for adequate infrastructure development and ultimately guaranteeing adequate

220. See chapter 1, section 3.1 "Liberalisation" and Tooraj Jamasb and Michael Pollitt, 'Security of Supply and Regulation of Energy Networks' (2008) 36 Energy Policy 4584-4589, 4585.
221. See chapter 1, section 2 "Evolution - The Setting of the Electricity System".
222. Electricity system reliability can be measured with the System Average Interruption Frequency Index (SAIFI), which is the average number of interruptions that a customer would experience, and the System Average Interruption Duration Index (SAIDI), which is the average outage duration for each customer served.
223. Iñigo del Guayo and Johann-Christian Pielow, 'Electricity and Gas Infrastructure Planning in the European Union', in Martha Roggenkamp, Lila Barrera-Hernández, Donald Zillman, and Iñigo del Guayo (eds) *Energy Networks and the Law: Innovative Solutions* (Oxford University Press 2012) 353-370, 353.

transmission and distribution infrastructure.[224] The further establishment of the internal market for electricity also depends on adequate transmission and distribution capacity, more specifically, the interconnection of networks across national borders in order to facilitate the necessary physical interconnections of the internal electricity market. In addition to adequate physical interconnections, interconnected electricity networks also require higher levels of coordinated planning and operation. Regarding this issue, the third EU legislative phase[225] established, among other measures, the drafting of network codes for cross-border exchanges on EU level.[226] Additionally, and with the growing importance of electricity system interconnection for the establishment of the internal market, also the electricity market Directive 2009/72 aims at ensuring adequate transmission and distribution infrastructure by defining *"long-term planning"* as

> *"the planning of the need for investment in generation and transmission and distribution capacity on a long-term basis, with a view to meeting the demand of the system for electricity and securing supplies to customers".*[227]

This is further given form under the establishment of the tasks of the designated transmission and distribution system operators.[228] However, the responsibility for ensuring adequate capacity is more elaborately addressed for the TSO, than for the DSO. Article 12(c) of Directive 2009/72 specifically states *"each transmission system operator shall be responsible for:* […] *contributing to security of supply through adequate transmission capacity and system reliability"*. This governance approach is tailored for a centrally organised electricity sector with large generation installations connected to the transmission system, and where the transmission system serves as *"backbone"* for electricity transmission and market integration. Subsequently, Directive 2009/72 establishes rules for *"network development and powers to make investment decisions"* specifically for the TSO.[229] Central to this provision is the national "ten-year network development plan" (NTYNDP). The designated TSO of each member state has to draw such a plan every year for the next ten years. The provision establishes that "[the] *network development plan shall contain efficient measures in order to guarantee the adequacy of the system and the security of supply."*[230] This provides the TSOs with considerable power

224. Stian Antonsen, Petter Almklov, Jørn Fenstad, and Agnes Nybø, 'Reliability Consequences of Liberalization in the Electricity Sector: Existing Research and Remaining Questions', (2010) 18(4) Journal of Contingencies and Crisis Management 208-219, 216.
225. See chapter 1, section 3.1 "Liberalisation".
226. Regulation (EC) No 2009/714 on Conditions for Access to the Network for Cross-Border Exchanges in Electricity and repealing Regulation (EC) No 1228/2003 [2009] OJ L211/15. In the following Regulation (EC) No 2009/714.
227. Art. 2(25) Directive 2009/72/EC.
228. Art. 12 for the for the TSO and art. 24 for the DSO.
229. Art. 22 Directive 2009/72/EC.
230. Art. 22(1) Directive 2009/72/EC.

over the design of their transmission system as it is mainly based on their assumptions about the evolution of generation, supply, consumption, and exchange with other countries.[231] While this setting fits a centrally-organised sector with large generation connected to the transmission system, ensuring adequacy by enabling options at distribution system level might be overlooked and underestimated.

The incorporation of the policy objective to ensure adequate electricity systems is clearly incorporated in the EU legal framework of the electricity sector. Especially, the liberalisation of the sector and subsequent need to further expand the interconnection of networks required coordination of this objective across national borders. The interconnection of networks across borders is exclusively deployed at transmission system level. However, increasing amounts of decentral generation, prosumption and demand flexibility options would require to set out the development of legislation which also addresses the distribution system level for ensuring the policy objective to ensure adequate distribution capacities. SES might further improve the implementation of the policy objective "adequacy" at distribution system level. This is discussed in section 3 of this chapter.

2.2.2 Affordability

The policy goal "affordability" means maintaining prices for electricity supply and electricity transport economical in order to ensure reasonable supply- and transport prices for consumers, and in particular small consumers (residential consumers and small enterprises connected to the distribution system). The current legal framework incorporates this objective in two main fields, namely consumer protection measures, for example with regulated supply prices, and regulation of system operators, more specifically, the oversight and approval of network tariffs for transport. The composition of the final electricity price (including the commodity- and the transport costs) for household consumers in the EU varies greatly.[232] However, a general trend of the average price for the commodity shows

> "[…] *that the relative share of the energy component in the final price has declined considerably over the recent years from 41% in 2012 to 35% in 2017, which reflects the decreasing wholesale electricity prices and better market functioning.* […] *At the same time, the share of network component remained almost unchanged."*[233]

231. Art. 22(3) Directive 2009/72/EC.
232. In addition to the commodity price and the network costs, the final retail price also includes VAT, taxes, and surcharges for the support of RES. For the purpose of this thesis, this section focuses on the network charge component.
233. For example, the commodity component, electricity supply, accounted for 78% of the final bill in Malta, but only for 14% in Denmark. ACER, 'ACER/CEER - Annual Report on the Results of Monitoring the Internal Electricity and Natural Gas Markets in 2017 – Electricity and Gas Retail Markets Volume' (22 October 2018) 16.

In an electricity sector with increasing amounts of RES, decentral generation, prosumption, and demand flexibility, the price for the commodity electricity will increasingly decline, however, the costs for maintaining the system in balance and system operation in general, are likely to raise with increasing amounts of variable RES connected to the system.[234] This further leads to the question how to ensure the policy objective “affordability” in the context of “the electricity sector in flux” which changes the current use patterns of the electricity system and the associated costs. As the introduction of this thesis explained, one of the core issues of SES is the distribution of these costs for network usage. Therefore, this section focuses on the policy objective “affordability” with a focus on the costs of network usage by outlining the complexity of tariff setting. While the majority of issues outlined in this section is applicable to electricity transport tariffs in general (transmission and distribution), for the purpose of this thesis, which focuses on developments at distribution grid level, the distribution tariff is addressed in particular in this section.

The overarching goal of the liberalisation of the electricity sector is increasing overall welfare by improving efficiency through a competitive market setting.[235] The main tool to achieve this goal is unbundling between potential market- and grid-related activities in the electricity sector, so that market competition can flourish at least in generation and supply of electricity. While in generation and supply of electricity the policy goal affordability is to a large extent left to market forces which are balanced with consumer protection measures, this is not the case for network activities as they constitute a natural monopoly. Therefore, the remuneration of network operation is determined by tariff regulation essentially controlling the income of the system operators and thereby preventing them from charging unreasonably high tariffs for system use. The detailed calculation method of network tariffs is subject to national legal regimes, EU law only establishes general criteria.[236] Despite transparent and controlled calculations, regulating network tariffs is complicated, not at least due to the information asymmetry between the system operators and the supervising body, the NRAs. Much discussion surrounds the question how to establish the right balance among affordability for system users, recovery of operational costs for system operators, and also sufficient investment signals for system operators to develop new infrastructures and venture innovation which improves system operation. At the core of this balancing problem is the natural monopoly character of the system operators, which grants system operators extensive power over information of the actual network costs.

234. Joan Batalla-Bejerano and Elisa Trujillo-Baute, ‘Impacts of Intermittent Renewable Generation on Electricity System Costs’ (2016) 94 Energy Policy 411-420, 418.
235. See chapter 1, section 3.1 “Liberalisation”.
236. Art. 15 and annex XI Directive 2012/27/EU.

> "[…] *the total of all charges to all users must be sufficient to cover the costs of the network and afford the network company an adequate return on its capital. On the other hand, the total of all charges should be kept reasonable, in the sense that the network company is not extracting monopoly profits."*[237]

One of the guiding criteria for network tariff setting which is also established in EU legislation as core principle, is cost-reflectivity.[238] This entails, in simple terms, that the tariff has to reflect the costs incurred by the system users, and *vice versa*. It is thus not ensured, "[…] *if the user will not face a lower tariff if their network usage is reduced, as the relationship between the network usage and the tariff paid is lacking.*"[239] As the exact design of network tariffs is subject to national legislation, various different models of methodologies underlying the calculation of network tariffs exist, with the main difference being the energy component (volume) determining the charge or the capacity.[240] Both options are discussed further in chapter 4 of this thesis.[241] While ensuring the principle of cost-reflectivity is already challenging and exact implementation is discussed, the development of DG, prosumption, and demand flexibility expectedly further increases the complexity of ensuring cost-reflectivity.[242] The usage patterns of residential consumers, who have so far been considered as homogenous group, will considerably differ depending on whether they engage in generation or demand flexibility. This also affects their impact on electricity system costs. This issue is further subject to chapter 4. At this point, it is relevant to mention that with the "electricity sector in flux", it becomes more complex to implement and monitor the current guiding principle for network tariff design, cost-reflectivity. However, the regulatory authorities need to handle realistic criteria for approving network tariffs in order to further ensure that system operators are not exploiting their natural monopoly and ask discretionary network tariffs from their system users, in order to ensure the policy objective "affordability" of transport, specifically, distribution, of electricity.

2.2.3 Sustainability

With the global aim to reduce GHG emissions for the sake of climate change mitigation and commitment of the EU thereto, the EU progressively included measures directed

237. Vivek Sakhrani and John Parsons, 'Electricity Network Tariff Architectures – A Comparison of four OECD Countries', (10 July 2010) Massachusetts Institute for Technology, Center for Energy and Environmental Policy Research (CEEPR) No. 10-008 4.
238. Annex XI (1) Directive 2012/27/EU.
239. Michiel Nijhuis, Madeleine Gibescu, and Sjef Cobben, 'Analysis of Reflectivity and Predictability of Electricity Network Tariff Structures for Household Consumers' (2017) 109 Energy Policy 109 631-641, 632.
240. Commission of the EU, 'Study on Tariff Design for Distribution Systems' 28 January 2015.
241. See chapter 4, section 2.2.1.1 "Smart" Distribution Network Tariff Structures".
242. Michiel Nijhuis, Madeleine Gibescu, and Sjef Cobben, 'Analysis of Reflectivity and Predictability of Electricity Network Tariff Structures for Household Consumers' (2017) 109 Energy Policy 109 631-641, 640.

to that purpose in the its legal framework of the electricity sector. Legislation mainly includes the promotion and support of RES and measures which aim at reducing GHG emissions. Often, this is referred to in policy documents as facilitating a *"sustainable"* electricity sector.[243] This section does not aim at setting out the legal framework exhaustively, as the relevant legislation related to the aim to lower carbon-emissions in the sector, specifically on RES promotion, was outlined in the previous chapter.[244] Instead, this section aims at relating the broad policy goal which is named here *"sustainability"* to the preceding two goals and thereby complete the picture, and the resulting trilemma, of the main EU policy goals for the electricity sector. The preceding sections already identified difficulties in striking a balance among different policy goals in the electricity sector (for example between economic efficiency and the need for investments and different levels of decision-making between the EU- and national levels).[245] The policy goal to achieve a "sustainable" electricity sector adds to the complexity of balancing goals on different decision-making levels and maintaining their integrity. Completing the picture will further contribute to understand the need for technical innovation, the rationale for SES, which ideally enable reconciling the policy trilemma and at the same time maintaining the technical functioning of the electricity system. This section briefly outlines the development of the policy goal "sustainability" in general, and in particular its role in the EU electricity sector. Relating this objective to the overall theme of this section, this section further identifies the main challenges of combining a "sustainable" electricity sector in the technical system that was characterised by limited grid capacity which needs to be balanced and coordinated.

The general policy goal "sustainability" emerged in the international arena which was introduced by the UN and subsequently diffused in EU energy policy. Most famously, the concept of sustainability was coined by the World Commission on Environment and Development (also known as the *Brundlandt Commission*), which was set up by the UN in order to address sustainable development on an international level.[246] The *Brundlandt Commission* published a final report which defined *"sustainable development"* as *"development that meets the needs of the present without compromising the ability of future generations to meet their own needs."*[247] While the definition is appealing, it also remains abstract and vague. Yet, without much further specification, sustainability

243. See policy documents mentioned in footnote 13
244. See chapter 1, section 3.2 "Climate Change Mitigation".
245. See also chapter 1, section 3.2.3 "20/20/20 Strategy and Beyond".
246. The UN established the Commission in 1983 and dissolved the Commission officially in 1987 after releasing the final report named *Our Common Future*. For a detailed analysis of the emergence of the concept 'sustainable development' as an international policy objective see Patricia Birnie, Alan Boyle, Catherine Redgwell, *International Law and the Environment,* (3rd ed Oxford University Press 2009) 53-54.
247. World Commission on Environment and Development, *Our Common Future,* 41.

emerged as an accepted concept also in EU policy. Sustainability was brought forward in the "Europe 2020 strategy" titling *"a strategy for smart, sustainable and inclusive growth"*. Here, *"sustainable growth"* is further explained as *"promoting a more resource efficient, greener and more competitive economy"*.[248] The objective to achieve sustainable growth also diffused into EU energy policy which materialised in the *"Energy Roadmap 2050"*. The Roadmap characterises sustainability in the energy sector by two guiding measures namely energy efficiency and RES.[249] These measures are specifically incorporated in two Directives on the promotion of renewable energy sources and on energy efficiency measures. While those Directives mainly set targets and measures to prioritise RES and energy efficiency, the Regulation on guidelines for trans-European energy infrastructure (347/2013) additionally emphasises that energy infrastructures are a key element to achieve *"resource efficiency and integration of renewable energy sources"*.[250] Setting targets is thus just one side of the story as the technical electricity system, the physical infrastructure, also needs to be capable to integrating RES and energy efficiency measures. This is more difficult to achieve than setting targets and subsequent priority measures. The legal obligations of RES and energy efficiency targets are posing a challenge to the technical electricity system, more specifically, the operation thereof. The variable character of RES causes larger fluctuations in generation which do not necessarily coincide with consumption periods. This requires reinforced grid infrastructure for capturing larger generation peaks and additional balancing generation reserves which ensure supply when RES are not available. Facilitating the integration of RES and energy efficiency measures in this way however, would first of all not lead to the desired low-carbon electricity sector and fuel independency from third states and secondly would also exacerbate the above mentioned policy goal trilemma among adequacy, affordability, and sustainability. This is further highlighted in the following section.

2.3 Clash between Technical Requirements and Policy Aspirations

The preceding sections provided an overview of the relation between the technical component of the electricity system and the organisational component which entails three main policy objectives for the electricity sector. While the technical component is characterised by limited grid capacity and complexity of load forecasting for various time-frames, the organisational component prescribes three main policy goals to be realised in the electricity sector which aim at serving society at large and which pressure the technical integrity of the electricity system. The policy goals are strongly

248. Commission of the EU, 'Europe 2020 - A Strategy for Smart, Sustainable and Inclusive Growth', COM(2010)2020, 3.3.2010.
249. Commission of the EU, Communication on Energy Roadmap 2050, COM(2011)885 final, 15.12.2011, 9-10.
250. Recital 1 Regulation (EU) No 2013/347.

interwoven *inter se* and can hardly be analysed without acknowledging the importance of the respective other goals. Therefore, the above identification and analysis of the three main policy goals remains limited. Yet, the chosen aspects show that policy goals have a strong impact on the design of the electricity system and that prioritising one over the other would lead to various different outcomes and settings. Aligning the technical- and the organisational component bears potential conflicts and requires prioritising interests in their implementation. This also illustrates the political sensitivity of electricity sector policies and their incorporation in a legal framework.

The core aim for the future electricity sector is to maintain the technical integrity of the grid and at the same time ensuring the policy objectives. The introduction of this chapter stated that maintaining the technical integrity and the policy objectives in the "electricity sector in flux" becomes even more difficult as the technical options and actors in the electricity sector multiply. This requires new forms of coordination and cost-distribution of electricity system usage, especially at distribution system level. The following sections introduce smart electricity systems as a potential solution to the problem of reconciling the technical integrity of the system and maintaining the policy objectives.

3. SMART ELECTRICITY SYSTEMS AND THE QUEST FOR A NOVEL LEGAL FRAMEWORK

The introduction of this thesis already mentioned that much confusion exists about what SES are, or better, what they are anticipated to be.[251] Especially definitional approaches lack in capability of capturing SES, as they tend to be composed of only more terms raising questions and thereby strand in meaningless tautologies. Therefore, this thesis does not aim at asserting a general and complete definition of SES. On the contrary, this thesis aims at showing that there can be no single definition, rather a range of understanding of elements which can be included in SES and which are necessary for a defined goal. In that sense, the specified goal becomes of greater relevance than the specific technology deployed. What this means for the legal framework is not addressed in this chapter, but in the following chapter 3. The following sections outline the main goals ascribed to SES, which are understood as a solution to the above outlined policy goals trilemma and related technical challenges. Several objectives can be attributed

251. See Introduction: Unlocking Flexibility with Law, section 2.1 "Aim and Scope" and Anne Beaulieu, 'What are Smart Grids? Epistemology, Interdisciplinarity and Getting Things Done' in Anne Beaulieu, Jaap de Wilde, and Jaquelien Scherpen (eds), *Smart Grids from a Global Perspective: Bridging Old and New Energy Systems* (Springer 2016) 63-73.

to SES which are outlined in section 3.1 as part of the technical component. Section 3.2 then concludes that realising these objectives, requires a legal framework which enables and incentivises SES.

3.1 Technology Component: Smart Electricity System Objectives

Avoiding the pitfall of establishing an incomplete and largely meaningless definition of SES, this section aims at explaining SES along the key objectives attributed to SES. This approach is useful for the two following reasons: firstly, it allows understanding SES primarily as technical solution for the above outlined policy trilemma and related technical challenges, which are exacerbated by developments of "the electricity sector in flux". Secondly, it further elucidates the rationale behind SES. This approach, which builds upon identifying a problem and subsequently formulates goals for its solution, is borrowed from the FULDA-method[252] which was outlined in the introduction chapter of this thesis.[253] The FULDA-method establishes that

> *"if we want to design anything new, there is a 'problem' for which the design is supposed to be the solution. From the formulation of the problem we can arrive at defining the goals for the object to be designed".*[254]

In line with this approach, this section introduces SES as a *"design solution"* for the near-future electricity sector which reconciles the above outlined policy objective trilemma. Understanding SES along their main attributed objectives allows a largely technology-neutral approach which prevents from stranding in ever incomplete technology listings. Before further explaining technology-neutrality and what this means for a legal framework for SES (chapter 3), this section needs to set out the goals assigned to SES.

Determining the relevant objectives assigned to SES, two existing descriptions of the term "smart grid" provide guidance. The International Energy Agency (IEA) compiled a consensus view of various governments around the globe, industry, academia, and consumer representatives on the term "smart grid". As wide as the views taken into consideration, as broad is their description of what "smart grids" are anticipated to achieve. Yet, their description provides a starting point in distilling global objectives of "smart grids".

252. Recalling, FULDA is the abbreviation for "function-based legal design & analysis".
253. See Introduction: Unlocking Flexibility with Law, section 2.5 "Methodology and Approach".
254. Hamilcar Knops, *A Functional Legal Design for Reliable Electricity Supply – How Technology Affects Law* (Energy & Law Series 6 Intersentia 2008), 91.

> *"Smart grids can play an important role in addressing increasingly untenable economic, environmental, and social trends in the supply and use of energy. By enabling increased awareness of system operation and better informed participation by electricity users, smart grids will increase electricity end-use efficiency while optimising network asset utilisation and increasing grid resiliency. They will also enable efficient integration of variable renewables and electric vehicles, as well as new products and services."*[255]

The first sentence of the description refers to the policy objective trilemma. Although using a different terminology (economic, environmental, and social), this description of "smart grids" also promotes "smart grids" as a approach to solve this trilemma. This approach includes four broad goals, namely: Participation of electricity user (demand side), energy efficiency (in system operation and end-use), grid resilience, and integration of variable RES.

In addition to this global description by the IEA, EU legislation also aims at capturing and promoting the term "smart grids" by defining it as follows:

> *"'smart grid' means an electricity network that can integrate in a cost efficient manner the behaviour and actions of all users connected to it, including generators, consumers and those that both generate and consume, in order to ensure an economically efficient and sustainable power system with low losses and high levels of quality, security of supply and safety."*[256]

Again, in different terms, the policy trilemma is mentioned as central problem to which "smart grids" are the anticipated solution by stating "[…] *in order to ensure an economically efficient and sustainable power system with low losses and high levels of quality, security of supply and safety."* Similarly, to the description of the IEA, the EU definition also identifies the goal of increased levels of participation of system users, specified by generators, consumers, and prosumers.

Next to these descriptions of "smart grids" or SES, and their objectives, the term "smart" deserves some further elaboration at this point. The use of the attribution "smart" might be explained by two related dimensions, namely why and how SES reconcile the policy trilemma. The why-question refers to the underlying idea of SES to consider all policy objectives of the trilemma equally, meaning *vice versa*, it would not be "smart" to only focus on the accomplishment of one of them as this would result in various

255. IEA, "Technology Roadmaps: Smart Grids" (2011), 6.
256. Art. 2(7) Regulation (EU) No 2013/347.

costs for society at large. The how-question, refers to the way in which SES achieve the reconciliation of the trilemma, namely by interconnection system users *inter se* and system users with system operators by communication infrastructure, facilitating data exchanges among them. The data contains information on the availability of energy- and grid capacities and contains a price signal which ideally incentivises system users to adjust their usage pattern. This is explained further below in the following subsections and also in the following chapters. Here, it is relevant to mention that the attribution "smart" refers to information compilation and coordination.

As mentioned above, definitions do not necessarily further the understanding of what "smart grids" or SES are. Subsequently, existing definitions do not clarify the relevant implications of SES necessary for the development of a legal framework which enables and incentivises SES. While the two descriptions of the IEA and the EU thus do not suffice for developing a legal framework for SES, they yet entail objectives that SES are envisaged to fulfil. In line with the FULDA-method, from the identification of the policy trilemma problem, "[…] *we can arrive at defining the goals for the object* [SES] *to be designed"*.[257] The following four overarching objectives are identified: improving energy efficiency, integrating RES, maintaining grid resilience, and involving system users. The subsequent sections introduce each of those objectives and outline how SES are contributing to its achievement. The objectives are strongly interwoven in SES and can therefore only jointly contribute to further understand SES and subsequently further the development of a legal framework which enables and incentivises SES. The order of their subsequent presentation in the following sections does thus not imply a specific priority of the goals, as they can only jointly function in SES.

3.1.1 Energy Efficiency

Generally, improving efficiency always requires comparing alternatives regarding their differences in resource uses for a certain process. This is because efficiency is nothing absolute, but something which compares to something else in terms of efficiency for a specified resource, that could be, for example, time, money, energy, or a combination thereof. In the electricity sector, efficiency thus means comparing alternatives for grid design and system operation regarding electricity losses and the need for balancing generation reserves. The difficulty in reducing wastages lies in the technical nature of electricity which requires the grid to be in balance at all times. Developments of "the electricity sector in flux" exacerbate imbalances at distribution system level, as greater peaks of variable decentral RES, bidirectional electricity flows caused by

257. Hamilcar Knops, *A Functional Legal Design for Reliable Electricity Supply – How Technology Affects Law* (Energy & Law Series 6 Intersentia 2008), 91.

prosumption, and increasing consumption, for example for electric vehicles, need to be accommodated by the electricity system. One way to accommodate those peaks is to reinforce the grid infrastructure and to install more generation reserves to balance the variable character of RES. In contrast to this approach, an alternative are SES. Instead of increasing grid capacities and generation balancing reserves, at the core of the idea of SES is using existing capacities efficiently by harnessing flexibilities in generation and especially in demand to operate the system.

The current electricity system is designed to satisfy electricity demand at any time, which is determined by the peak load forecasts.[258] This design approach leaves a great proportion of the grid idle for most of the time. Increasing amounts of RES exacerbates this problem due to their variable character. This is even more severe for the distribution system, where transport losses are significantly higher and decentralised generation and prosumption add bidirectional electricity flows.[259] From a technical perspective several measures exist to reduce those transport losses, *"these include changes to the network design, such as specifying larger assets to reduce resistance, operational schemes, and low-loss-transformers."*[260] SES provide a different approach compared to those technical measures to reinforce the grid infrastructure. Instead of reinforcing existing infrastructure which is capable of capturing peaks, SES improve energy efficiency by including the demand side in matching generation and consumption.[261] The idea is that electricity demand can follow supply in order to better align peak-generation with consumption. In this way, SES are considered an alternative to conventional network enforcement which averts the need for reinforcing existing infrastructures.[262] SES thus aim at improving energy efficiency by matching consumption with generation, which becomes more relevant with increasing amounts of variable RES generation. How this "matching" is done, is explained further below in the section on "system user centricity" (section 3.1.4). Essentially, this would also reduce the need for balancing generation reserves on basis of conventional, fossil-based energy sources. This leads to the following objective assigned to SES, the integration of RES.

258. See chapter 1, section 2.1 "Technical Component" and also section 2.1 of this chapter on "Technology Component: Load Forecasting".
259. Ecofys (2013). Incentives to Improve Energy Efficiency in EU Grids. By order of European Copper Institute 15 April 2013, 2.
260. Rita Shaw, Mike Attree, Tim Jackson, and Mike Kay, 'The Value of Reducing Distribution Losses by Domestic Load-Shifting: A Network Perspective' (2009) 37 Energy Policy 3159-3167.
261. Pedro Moura, Gregorio López, José Moreno, and Aníbal De Almeida, 'The Role of Smart Grids to foster Energy Efficiency' (2013) 6 Energy Efficiency 621–639, 624.
262. Rahmatallah Poudineh and Tooraj Jamasb, 'Distributed Generation, Storage, Demand Response and Energy Efficiency as Alternative to Grid Capacity Enhancement' (2014) 67 Energy Policy 222-231, 223.

3.1.2 Renewable Electricity Sources

The deployment of SES is often associated with facilitating the integration of RES. Yet, this is not necessarily accurate, as the integration of RES can very well be accomplished with conventional grid design which would require reinforcing existing grid infrastructure (as outlined in the preceding section). A more refined consideration of the relation between SES and RES integration is closely related with the foregoing objective "energy efficiency". The severe problem of integrating large amounts of (possibly decentral) RES in the current electricity system is the variability of RES generation causing unforeseeable electricity flows. The conventional approach of electricity infrastructure planning based on load forecasting methods as explained in section 2.1 becomes insufficient as the maximum generation capacity of the RES is decisive. This would lead to largely oversized grid infrastructure which remains unused for the majority of the time. As mentioned in the preceding section, SES apply a different approach by matching consumption with generation. The integration of RES by SES has to be seen in relation to efficiency, so contrary to conventional grid design SES facilitate the efficient integration of RES.[263]

2

Against the background of "the electricity sector in flux", the distribution grid operation is becoming increasingly difficult with unpredictable generation and consumption. The distribution system and even more the operation of the distribution grid were mainly designed and equipped for "forwarding" electricity flows from the transmission level via the distribution grid to the points of consumption.[264] DG, prosumption, and increasing demand thus cause disturbances to the current approach of distribution system operation. More technologies and actors need to be taken into consideration. The efficiency integration of RES at distribution grid level under these circumstances becomes difficult, if not impossible. One of the assigned objectives to SES is to enable the efficient integration of RES at distribution system level by facilitating information exchanges on generation and consumption and available grid capacities in real-time. This would enable better coordination for distribution operational purposes. The following objective assigned to SES, maintaining grid resilience in spite of growing complexity at distribution grid level, adds thereto.

3.1.3 Grid Resilience

The term "resilience" was briefly introduced in chapter 1 and broadly explained as the ability of the electricity system to respond to disturbances. Furthermore, the "electricity

263. Monowar Hossain, N. Madlool, N. Rahim, Jeyraj Selvaraj, A. Pandey, Adarsh Faheem Khan, 'Role of Smart Grid in Renewable Energy: An Overview' (2016) 60 Renewable and Sustainable Energy Reviews 1168-1184.

264. Guillermo Pereira, Jan Specht, Patrícia Pereira Silva, and Reinhard Madlener, Technology, Business Model, and Market Design Adaptation Toward Smart Electricity Distribution: Insights for Policy Making' (2018) 121 Energy Policy 426-440, 428.

system in flux" and the emergence of increasing amounts of decentral generation and "prosumption", and raising electricity demand were identified as such disturbances to the technical and organisational integrity of the electricity sector.[265] Currently, resilience of the system is mainly ensured at transmission level, to which the large majority of generation is connected. System balancing is undertaken by the TSOs at transmission level on the basis of precise data on generation, loads, and capacities. One of the objectives of SES is to restore grid resilience in "the electricity sector in flux" by means of information exchanges among system users and between system users and system operators on energy- and grid capacities close to real-time at distribution system level.

At a first sight, the concept of grid resilience seems closely linked to what was outlined above as the policy objective "adequacy" of the electricity system. However, maintaining the electricity system adequately with current grid design- and operation approaches becomes increasingly difficult in "the electricity sector in flux". The term "resilience" thus extends beyond the understanding of an adequate system by stressing the inclusion of flexibility.[266] Central for resilience is the ability of the sector to cope with imminent threats to the functioning of the electricity system.[267] Grid resilience is a very broad concept and captures a range of dimensions of the electricity sector from resource availability to system functioning.[268] Improving resilience for one dimension in the electricity system could very well be contradictive to resilience in another aspect. For example, the deployment and integration of (decentral) RES generation improves resilience in terms diversification of supply sources, and contributes to climate change mitigation.[269] From a system operation perspective, however, the increasing deployment of decentral generation based on variable RES cause disturbances to the current operation of the electricity system which was designed for a grid system with large remote controllable generation with electricity flows from the transmission level via the distribution level to the points of final consumption. This illustrates the complexity to achieve overall resilience as various dimensions are interdependent in the electricity sector. The factors disturbing resilience, which are subject to this thesis, are decentral generation on basis of variable RES, prosumption, and raising demand at distribution grid level. The core approach of SES to restore grid resilience is by means

265. See chapter 1, section 4.1 "Decentral Generation".
266. For a review of definitions of resilience in the context of electricity systems see Reza Arghandeh, Alexandra von Meier, Laura Mehrmanesh, and Lamine Mili, 'On the Definition of Cyber-Physical Resilience in Power Systems' (2016) 58 Renewable and Sustainable Energy Review 1060-1069.
267. See Geoff O'Brien, 'Vulnerability and Resilience in the European Energy System' (2009) 20(3) Energy and Environment 399-410.
268. Lynette Molyneaux, Liam Wagner, Craig Froome, and John Foster, 'Resilience in Electricity Systems: A Comparative Analysis' (2012) 47 Energy Policy 188-201.
269. Geoff O'Brien and Alex Hope, 'Localism and Energy: Negotiating Approaches to Embedding Resilience in Energy Systems' (2010) 38 Energy Policy 7550-7558, 7551.

of information and communication technologies (ICT), which facilitate a constant exchange of information on grid capacities, generation and loads at distribution grid level.[270] This implies engaging system users at the distribution grid level in novel ways. The following section therefore introduces the final objective ascribed to SES, namely system user centricity.

3.1.4 System User Centricity

Accomplishing the above identified objectives requires placing system users more central in the electricity sector. In that sense, the focus on system users is less an objective itself, but a way of achieving the other identified SES objectives. As already briefly outlined, maintaining grid resilience at distribution grid level in spite of increasing amounts of decentral generation on basis of variable RES, prosumption, and raising demand requires detailed information on available capacities in the electricity system. This information needs to be provided by the system users who are connected to the distribution grid. These system users can be consumers, producers, or prosumers with varying consumption and grid usage patterns. Merely collecting the information about their consumption and grid usage patterns is, however, not sufficient. The information also needs to be used in order to coordinate energy- and system use. To this end, SES entail attributing varying, often referred to as dynamic, prices to the varying, energy- and grid capacities and communicating these prices to the system users. Ideally, the dynamic prices then incentivise system users at distribution grid level to adjust their electricity generation, consumption and grid usage. This shifts the focus towards system users and their ability and willingness to flexibly adjust their demand incentivised by the pricing system.[271] This implies that consumers need to adjust their demand according to the availability, which is assigned a specific price, of supply (for example variable RES).

Ideally, unlocking flexibilities of system users in grid usage and electricity consumption would enable matching consumption with generation rather than providing endless generation, transmission, and distribution capacity to satisfy demand at any time. This would be accomplished by introducing a market mechanism for energy consumption and grid usage in real-time, or at least close to real-time. Currently, the tariff for grid usage and energy supply prices are often fixed and do not change, even though the actual costs of grid usage and energy consumption do vary. The varying costs are socialised among the system users. However, with increasing amounts of RES connected to the distribution system and with a variety of technologies creating new demand patterns

270. Yakubo Tsado, David Lund, and Kelum Gamage, 'Resilient Communication for Smart Grid Ubiquitous Sensor Network: State of the Art and Prospects for Next Generation" (2015) 71 Computer Communications 34-49, 34.
271. Geert Verbong, Sjouke Beemsterboer, and Frans Sengers, 'Smart Grids or Smart Users? Involving Users in Developing a Low Carbon Electricity Economy' (2013) 52 Energy Policy 117-125, 120.

of consumers, the discrepancy of costs between different system users grows. The shift towards system user centricity has thus a twofold objective. Firstly, coordinating energy and grid capacities with the aim to enable the efficient integration of RES by using flexibilities of system users. Secondly, redistributing costs of grid usage and energy consumption according to individual system users. In that way, more flexible consumption patterns which contribute to lower system costs are rewarded, while less flexible consumption patterns are more expensive.

The involvement and central role of system users implies the need for most extensive changes to the organisational component of the electricity sector and subsequently the legal framework which assign rights and responsibilities to system users. Flexibility at distribution system level is a new value, which needs to be "unlocked", incentivised, by pricing mechanisms. A large extent of the remainder of this thesis thus focuses on the changing role of system users in SES as unlocking demand flexibility is essential for achieving the objectives ascribed to SES.

3.2 Organisational Component: The Quest for a Novel Legal Framework

The preceding section outlined four main objectives ascribed to SES. These objectives essentially aim at reconciling the policy goal trilemma and related technical challenges. Moreover, for the purpose of this thesis, these objectives ascribed to SES were introduced as "*goals for the object* [SES] *to be designed*".[272] Core to achieve the envisaged SES objectives is the integration of system users at distribution grid level as sources of flexibility. This was labelled as "system user centricity". Ideally, harnessing flexibility enables the efficient integration of decentral variable RES while maintaining grid resilience. To integrate these flexibilities, the electricity system needs to be sophisticated with ICT infrastructure which communicates energy- and grid capacities, and related prices, among the system users and system operators. Turning from the technology component and SES objectives to the organisational component of the electricity sector, the question is, what are the implications of integrating these objectives in the technical system for the organisation of the sector? The resulting question is central to this thesis, namely what are the key elements for a legal framework to enable and incentivise SES. This question is further structured and elaborated in the following chapters of this thesis, chapters 3 and 4. This chapter closes by providing insights in the need for- and the difficulty of developing a legal framework for innovations in the electricity sector.

272. See above section 3.1 "Technology Component: Smart Electricity System Objectives".

The value of flexibility was also recognised by the EU Commission establishing the "Energy Union Package" stating that harnessing flexibility of system users is considered as necessary as

> *"the growth of variable renewable energy makes demand response ever more important. Energy efficiency and demand response are often better options for balancing supply and demand than building or keeping in operation more power plants or network lines."*[273]

However, up until today SES have not been implemented and are far from being part of the planning and operational process in the electricity sector. EU-wide research on smart grid pilot projects establishes that obstacles for the implementation are especially existent in the governance and legal realm. The research concludes that

> *"the range of legal and regulatory arrangements in Europe might present significant barriers to the replicability of project results in different areas and to the scalability of projects to larger regions".*[274]

Not only is the range of legal and regulatory arrangements a barrier, but also its content which strictly regulates tasks between current actors of the conventional electricity sector and barely allows for novel organisational forms that allow and incentivise the implementation of SES and more specifically the integration of demand flexibility as core part of the electricity sector.

While the current legal framework assigns rights and responsibilities to actors in the sector according to the "top-down" supply chain of the electricity sector (meaning from large remote generation via transmission system to distribution systems, and eventually the points of consumption), SES require a legal framework which centres around flexibilities of system users and allows for new organisational forms which enable and incentivise the engagement of system users in flexibility provisions. A legal framework for SES would necessarily require rethinking the current roles of actors in the sector.[275] The following and final section of this chapter illustrates the resulting complexity for developing a legal framework for innovation in the electricity sector with a case study from the Netherlands.

---

273. Commission of the EU, Communication on Energy Union Package - A Framework Strategy for a Resilient Energy Union with a Forward-Looking Climate Change Policy, COM(2015)80 final, 25.2.2015, 5.
274. Commission of the EU, Joint Research Centre – Institute for Energy and Transport, 'Smart Grids Projects 2014 Outlook' (Publications Office of the European Union, 2014) 11.
275. Hans Vedder, 'De Regulering van Smart Grids – Naar Slimmere, Functionelere of vooral Complexere Regelgeving?' (2011)2 Nederlands Tijdschrift voor Energierecht 68-80 (only available in Dutch).

4. SEARCHING FOR NOVEL LEGAL FRAMEWORKS FOR INNOVATION IN THE ELECTRICITY SECTOR: A CASE STUDY FROM THE NETHERLANDS[276]

The foregoing sections yet again emphasised the connection between the technology- and organisational component of the electricity sector and concluded that realising SES requires the legal framework to enable and incentivise SES. In general, technical innovation potentially challenges existing legal frameworks as novel technical options might change actor roles and interaction possibilities among them and thereby distort incumbent orders which are enshrined in the legal framework. This section further illustrates the challenge in developing a legal framework for innovation in the electricity sector. The following subsections provide an example of an attempt to innovate the legal framework of the electricity sector in the Netherlands. The Netherlands is lagging behind in its RES share as established by Directive 2009/28. The EU Commission noticed that *"All but one Member State (the Netherlands) showed average 2013/2014 RES shares which were equal or higher than their corresponding indicative RED* [Renewable Energy Directive] *trajectory"*.[277] This gave rise in the Netherlands to initiate to further enable and incentivise the deployment of RES and energy efficiency measures, especially at distribution grid level. Acknowledging that this is not only a technical challenge, the Dutch legislator enabled what is referred to as *"experimental legislation"*.[278]

The following sections introduce this experimental legislation which allows for specified deviations from the current Dutch Electricity Act (hereafter: Dutch E-Act).[279] The aim of such deviations is to investigate whether new organisational forms accelerate the deployment of decentral RES and enable efficient grid operation in the electricity sector. The idea is to provide derogations from the existing, standard legal framework of the electricity sector to projects that contribute to distributed generation of RES and energy efficiency. If evaluations show that this is the case, the legislator may decide to adjust the legal framework accordingly. This case study does not in particular address the implementation of SES as introduced in this thesis, but at least several elements of SES (such as the integration of decentral RES and more efficient system operation). Above

276. This section (including the subsequent sections) is largely based on research conducted in the context of the present research project *SmaRds* and published in the following article: Imke Lammers and Lea Diestelmeier, 'Experimenting with Law and Governance for Decentralized Electricity Systems: Adjusting Regulation to Reality?' (2017) Sustainability 9(2) 212, 1-14. Additionally, the subject is addressed in Lea Diestelmeier and Dirk Kuiken, 'Legal Framework for Prosumers in the Netherlands' in Martha Roggenkamp and Catherine Banet (eds) *European Energy Law Report X* 151-167.
277. Commission of the EU, 'Renewable Energy Progress Report', COM(2017) 57 final, Brussels, 1.2. 2017, 9
278. Michiel Heldeweg, 'Experimental Legislation concerning Technological & Governance Innovation – an Analytical Approach' (2015) The Theory and Practice of Legislation 169-193, 176.
279. Elektriciteitswet 1998 Wet van 2 Juli 1998, houdende regels met betrekking tot de productie, het transport en de levering van elektriciteit, Stb. 1998, 427. In the following Dutch E-Act 1998.

that, this example can serve as a case study for understanding the dynamics between technological innovation and corresponding novel organisational forms which need to be codified in a legal framework. The following subsections set the background and outline the substance of the Experimentation Decree, and reflect upon the approach of regulated governance experimentation regarding the question in to what extent these projects can serve as a source of knowledge for developing a legal framework that is applicable on a larger scale.

4.1 The *Experimentation Decree* under Dutch Law

The guiding policy document in the Netherlands on the transition towards a more sustainable future is the "Agreement for Sustainable Growth" ("*Sociaal-Economische Raad Energieakkoord*", in the following "the Agreement") which was concluded between the Dutch government and the various stakeholders of the industry in 2013.[280] Amongst other measures, the document emphasises the potential of decentral generation of RES in contributing to the achievement of the goal of 14% of RES share in 2020 and 16% in 2023 as established by Directive 2009/28.[281] The Agreement acknowledges the current legal framework as an obstacle as it does not allow for new organisational forms and actors which particularly facilitate distributed generation on the basis of RES.[282] Therefore, the Agreement states that the legal framework of the electricity sector needs to facilitate innovation, in form of legal space for enabling new developments, such as decentral generation of RES.[283]

The Dutch Electricity Act provides the option for derogations from that Act in form of "experiments" which contribute to accelerating the development of generation, distribution, or supply of RES at distribution grid level.[284] Subsequently, the decree for experiments with decentral renewable electricity generation (in the following: *Experimentation Decree*)[285] establishes rules for such derogations for the purpose of increasing DG of RES and mitigating peak loads on the distribution grid. The Experimentation Decree allows small customers via collective entities not only to engage in collective generation of renewable electricity, but also to become supplier,

280. Energieakkord voor duurzame groei, Kamerstukken II 2012/13 30 196, nr. 202. In the following Energieakkord.
281. Energieakkord 11 and 79. For the Netherlands the target for the share of energy from renewable sources in gross final consumption of energy in 2020 is set at 14% (Art. 3(2) and Annex I, A. Directive 2009/28/EC). The total share of renewable energy consumption in 2014 was 5,5%. Commission of the EU, 'Renewable Energy Progress Report', COM(2017) 57 final, Brussels, 1.2. 2017, 9-10.
282. Energieakkord 83.
283. Energieakkord 83.
284. Art. 7(a) Dutch E-Act 1998.
285. Besluit van 28 februari 2015, houdende het bij wege van experiment afwijken van de Elektriciteitswet 1998 voor decentrale opwekking van duurzame elektriciteit (Besluit experimenten decentrale duurzame elektriciteitsopwekking, Besluit DDE), Stb 2015, 99. In the following Experimentation Decree.

and under certain conditions, even the system operator. Thereby the Experimentation Decree revokes the exclusive right of the DSOs to maintain and operate the part of the grid belonging to the project.[286] Projects applying for an exemption need to be operated by a legal entity which is either a cooperation or an owners' association and entirely controlled by its members. The control through its members is core to the Experimentation Decree, which is explained in its explanatory memorandum as changing the role from *"protected to empowered consumers"*.[287] Moreover, system operators and suppliers are not allowed to be a member of the collective entity, which emphasises the aim to investigate roles of potential new actors in the sector.[288] Certainly, the applicant still has to prove capability of the necessary organisational, financial and technical expertise required for the operation and supply of electricity.[289]

4.1.1 Substance

The Experimentation Decree provides three main exemptions from the Dutch E-Act. Firstly, an exemption can be granted from article 16(3) of the E-Act which prohibits any other party than a designated system operator to operate an electricity system.[290] Secondly, collective entities which have been granted an exemption automatically obtain the necessary license for electricity supply for the purpose of supplying the members of the cooperation or owner association of the project.[291] This allows the members to supply electricity to each other via the collective entity, which acts as the supply undertaking. Thirdly, the collective entity can determine their own network tariffs, as the NRA does not need to approve the specific tariff, but only the method of its calculation.[292]

The Experimentation Decree distinguishes between two sorts of projects which are determined by their size in terms of connected system users.[293] The most important difference in the applicable rules concerns the asset management and system operation of the grid. In contrast to the "project networks", "large project networks" require that

286. Art. 2 Experimentation Decree and art. 16 Dutch E-Act 1998.
287. Para. 1.5.1 Explanatory Memorandum Experimentation Decree.
288. Art. 3 Experimentation Decree. For more detail on the phenomenon of energy associations in the Netherlands see Maarten Arentsen and Sandra Bellekom, 'Power to the People: Local Energy Initiatives as Seedbeds of Innovation?' (2014) Energy, Sustainability and Society 4(2) 1-12.
289. Art. 7(1)(m) Experimentation Decree.
290. Art. 2 Experimentation Decree. This exemption contains some specific conditions regarding the size of the project, those are further outlined below.
291. Art. 13 Experimentation Decree.
292. Art. 12 Experimentation Decree.
293. So called "project networks" (in Dutch *project net*) have one connection to the public distribution system, are located within a geographically delineated area, and have a maximum of 500 connected customers. The other projects are called "large experiment projects" (in Dutch *groot experiment*). "Large experimental projects" take place within the existing service area of DSOs with a maximum of 10.000 customers connected to the system.

the asset management of the system remains an unbundled activity for the incumbent DSO. Asset management includes the development and maintenance of the technical components.[294] Yet, the collective entity may decide to designate a third party as the system operator with the task of system operation including the management of electricity flows, demand-response, and peak-shifting by means of ICTs.[295] The collective entities can thus act as an integrated electricity undertaking by acting as the generator, supplier, and under certain conditions, also as system operator.[296] Consequently, the strict division of market and network activities (unbundling) vanishes and the project operators take over the responsibilities of current DSOs and energy supply companies. This construction even includes the consumers as part of that undertaking as they are the members of the collective entity. This also leads to ambiguities regarding TPA.[297] The collective entity still needs to ensure TPA, which entails that consumers possess the right to choose freely for a supplier other than the collective entity. However, as the consumers are themselves part of the supplying entity it is unlikely that they choose another supplier, which potentially restricts competition for electricity supply. The whole setting of the collective entity is based on the contribution of the members and the members as consumers. The setting to collectively generate, distribute, and supply electricity can on the one hand be strong, but for the same reasons also be a weak governance construction. The underlying expectation is that repealing the current division of tasks which is tailored for a centrally organised electricity sector allows for new forms of organisation that are capable of efficiently deploying DG of RES. Ideally, new insights will provide a source of knowledge for developing a new legal framework which incorporates the desired shift towards more DG of RES as established by the "Agreement for Sustainable Growth".[298]

While the Experimentation Decree does not specifically address the implementation of SES, it does envisage closely related objectives (see section 3.1). Generally, the overarching aim is to facilitate the efficient integration of decentral generation based on RES and the efficient usage of grid infrastructure. Achieving this aim requires harnessing flexibility of system users and subsequently new organisational forms in the electricity sector. This has been acknowledged by the Dutch legislator who allows for new governance structures in the sector by means of derogation from the standard

294. Para. 2.3.3 Explanatory Memorandum of Experimentation Decree.
295. Para. 2.3.3 Explanatory Memorandum of Experimentation Decree.
296. Imke Lammers and Lea Diestelmeier, 'Experimenting with Law and Governance for Decentralized Electricity Systems: Adjusting Regulation to Reality?' (2017) Sustainability 9(2) 212, 10.
297. Hans Koenders and Simone Pipping, 'Het Besluit experimenten decentrale duurzame elektriciteitsopwekking doorgelicht' (2016) 4/2016 Nederlands Tijdschrift voor Energierecht 146-155, 152 (only available in Dutch).
298. Even though the Experimentation Decree does not specifically address SES it does address relevant components, efficient integration of DG of RES that are also envisaged in SES.

legal framework. However, the initial question of this section was to what extent these projects can serve as a source of knowledge for developing a legal framework that is applicable on a larger scale. The following section reflects thereon.

4.2 Legal Innovation put into Practice?

The approach of experimental legislation applied in the Netherlands aims at gaining knowledge for developing a legal framework which enables new forms of organisation which accelerate decentral generation of RES and efficient grid usage. Yet, a closer look discloses that the prescribed conditions of the projects limit the envisaged outcomes for application on larger scales. This limitation stems from the restricted character of the projects regarding the possibility of new actors to develop. The Experimentation Decree is limited to collective entities carrying out the majority of the tasks in the electricity supply chain. Essentially, this repeals the unbundling between grid- and market activities. While this might be successful within the experimental setting, it is questionable whether the outcomes can serve as input for application on larger scales. Whereas derogations from specific legal rules allow for derogations from the monopoly of DSOs, collective generation and supply, and dynamic electricity tariffs, the Experimentation Decree does not enable new actors and services to develop. Instead, the Experimentation Decree foresees a very strong role for the collective entity that is running the project. The (re-)bundling of supply chain activities with the collective entity provides no space for other innovative approaches to reach that goal. Therefore, it is likely that the outcomes will result in incremental knowledge instead of the envisaged new insights. It remains to be seen whether the first official evaluation (anticipated in 2019) will reveal similar conclusions.

For the development of a legal framework for SES, this case study shows that mere deviations from the existing legal framework are likely to strand in limited legal space for novel ways for new actors which enable novel ways of system operation. For the case of SES, the objective of "system user centricity" is essential for achieving all other associated objectives of SES, such as energy efficiency gains despite decentral generation, prosumption, and increasing demand, and grid resilience.[299] Harnessing flexibility on the demand side could be, for example, further enhanced by pooling flexibilities of various system users. New actors, often referred to as aggregators, could fulfil the role of pooling flexibility of generation and demand.[300] Enabling new

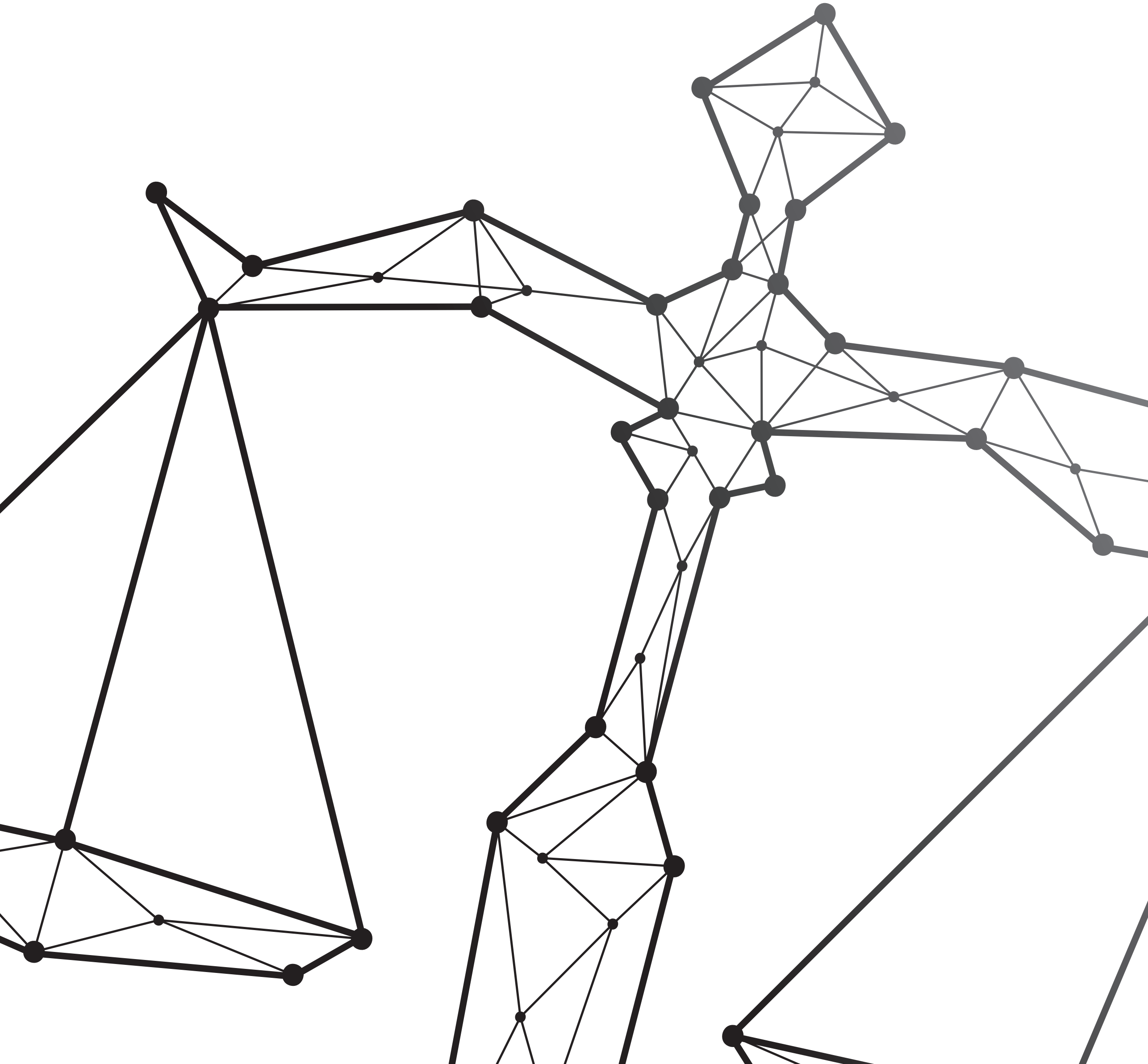
299. See section 3.1.1 "Smart Grid Objectives – System User Centricity".
300. Vincenzo Giordano and Gianluca Fulli, 'A Business Case for Smart Grid Technologies: A Systemic Perspective' (2012) Energy Policy 40 252-259, 253. For a perspective that focuses on the Netherlands see Adriaan van der Welle and Jeroen de Joode, 'Regulatory Road Maps for the Integration of Intermittent Electricity Generation: Methodology Development and the Case of The Netherlands' (2011) Energy Policy 39 5829-5839.

actors to play a role and contribute to enabling SES requires a different approach than providing deviations from the existing legal framework. The development of the legal framework needs to start at the functionalities of the system.[301] The following chapter specifies those functionalities which will then further lead to the development of a legal framework for SES.

5. CONCLUSION

This chapter argued that developing a legal framework which consolidates a specific design of the electricity sector depends on the policy goals and actors taken into consideration when developing that legal framework. The rationale underlying SES was established by identifying the EU policy objective trilemma and related technical challenges. While the technical objectives ascribed to SES aim at overcoming, or at least mitigating this challenge, SES also require new actors and coordination among actors which needs to be codified in the legal framework of the electricity sector. The difficulty in developing a legal framework enabling novel forms of organisation the electricity sector was illustrated by the example of experimental legislation in the Netherlands. Avoiding to strand with the problem of incremental knowledge generation by pilot projects, the following chapter establishes theoretical groundwork for developing a legal framework, which takes SES functionalities as starting point for a legal framework for SES.

301. See above section 3.1 "Technology Component: Smart Electricity System Objectives".



CHAPTER 3:

REGULATING FOR UTOPIA: THEORETICAL GROUNDWORK FOR A LEGAL FRAMEWORK FOR SMART ELECTRICITY SYSTEMS

1. INTRODUCTION

The foregoing chapter introduced SES as a technical solution for reconciling the EU policy goal trilemma (adequacy – affordability – sustainability) and maintaining the technical integrity of the electricity system. The simplified idea behind SES was identified as harnessing flexibility in generation and demand at distribution grid level in order to efficiently match both, this was introduced as "system user centricity". First findings of EU-wide smart grid pilot projects show that the legal framework does not enable the implementation of SES on larger scale.[302] The search for a legal framework which enables and incentivises SES is difficult, as pilot projects can only provide insights in the implementation of prior selected technologies and actors yielding narrow results. Increasing numbers of those projects will merely generate incremental knowledge on prior chosen aspects. Avoiding this pitfall, this chapter categorises more general functionalities of SES and then establishes theoretical groundwork for the development of a legal framework for SES. Thereby, this research continues to apply the system component-approach established in chapter 1 as the technology component of SES, SES functionalities, forms the basis of the search for the organisational component of the electricity sector, more specifically, a legal framework.

3

This chapter argues that the problem of incremental knowledge generation in the search for a legal framework for SES is rooted in the failure to overcome the rationale of the current legal framework of the electricity sector. The current rationale is based on the efforts to establish a liberalised electricity sector and to ensure supply at any time at affordable costs. Chapter 1 explained that the emergence of new actors and tasks was the result of unbundling the vertically integrated sector and liberalisation in general. The realms of generation and supply, system operation, consumer protection, and regulatory oversight are based on the regulatory distinction between market and network tasks. The technical options of SES, however, might change the current division of actors between market- and network tasks and subsequently render their current definitions nugatory. The majority of existing findings aiming at developing a legal framework for SES keeps redrawing the line between the incumbent actor definitions. In contrast thereto, this thesis does not take the existing definitions of actors, but the functionalities of SES as a starting point for developing a legal framework for SES.

Establishing a theoretical groundwork for the development of a legal framework for SES is necessary because SES are multifaceted systems which cannot be captured by an

302. Commission of the EU, Joint Research Centre – Institute for Energy and Transport, 'Smart Grids Projects 2014 Outlook' (Publications Office of the European Union, 2014), 11.

exhaustive list of technologies.[303] Regarding the need for an exponential development of technology, the understanding of SES must be sufficiently open in order to enable also technologies which are unforeseen at the moment. Against this background, the challenge is to develop a legal framework which is on the one hand sufficiently open, and on the other hand provides a sufficient degree of legal certainty. Those considerations shift the focus towards regulating effects instead of regulating specific means. To this end, this chapter explores the idea of technology-neutral regulation and goal-oriented regulation as techniques for developing a legal framework for SES. Thereby, this thesis proposes a framework for a feedback-loop from SES objectives (chapter 2), to the technical component of SES and theoretical foundations for a legal framework (chapter 3), and eventually to elements of the legal framework for SES (subsequent chapter 4). The implementation of a legal framework would then again connect to the objectives and an evaluation of their achievement (this final step is beyond the scope and time of this thesis).

This chapter unfolds in the following sections: According to the components of the electricity sector as established in chapter 1, this chapter starts by outlining the technology component of SES by identifying the main functionalities of SES. After that, section 3 contrasts the rationale of the current legal framework of the electricity sector with the technology component of SES. The section reveals that the convergences of technical functions in SES require a new organisational setting which cannot be based on the rationale of the current division of legal task. On the basis of those findings, section 4 establishes the theoretical groundwork by drawing analogies from the telecommunications sector which underwent profound regulatory changes as a response to technological innovation. The section introduces the legislative techniques of technology-neutral and goal-oriented regulation. Subsequently, section 5 establishes that a legal framework for SES needs to focus on the implications of the technical functionalities on the role of system users, the system, and interactions. Specific elements of such a legal framework are then further elaborated in the following chapter 4.

2. WELCOME TO *UTOPIA*: SKETCHING AN IDEAL SMART ELECTRICITY SYSTEM

This chapter poses that SES do not exist yet and remain up until now a utopian description of envisaged future electricity sectors. The preceding chapter introduced

303. See chapter 2, section 3 “Smart Electricity Systems and the Quest for a Novel Legal Framework”.

SES as a design solution for electricity systems which need to remain *adequate* and *affordable* and capable of integrating increasing amounts of distributed variable RES and thereby fulfil *sustainability* objectives.[304] Based on the SES objectives identified in the previous chapter, this section draws an ideal SES whilst focusing on the technical functionalities. "Ideal" means that this setting is not restricted by existing regulatory boundaries. This allows sketching a rough *"SES blueprint"* which further below in this chapter serves as a contrast to the current electricity sector and thereby explicates the limits of the current legal framework for the case of SES (section 3). In order to present a functional description of the technology component of SES, this section is largely based on secondary literature of technical disciplines. In line with the aim of this chapter, establishing theoretical groundwork for the development of a legal framework for SES which is based upon SES functionalities instead of upon incumbent actor definitions, the ongoing debate on legal issues is left aside in this section.

2.1 Technology Component: Operationalising Smart Electricity System Objectives

SES aim to reconcile the policy objective trilemma and to maintain technical integrity of the grid by including all components in the electricity supply chain, from generation to transmission and distribution, to consumption. The previous chapter decomposed this idea into four main objectives of SES.[305] Achieving those objectives requires their operationalisation by what is here referred to as "SES functionalities". Whereas objectives define *why* the transition towards SES is necessary (rationale), functionalities, additionally, describe *how* this could be achieved (operationalisation). In the context of the electricity sector, the term "function" can be defined as *"an ensemble of related activities that contributes to the functioning of the (electricity supply) system"*.[306] Against the background of the goal to increase the share of RES for climate change mitigation and fuel independency purposes and "the electricity sector in flux", for the purpose of this thesis this definition needs to be extended to "an ensemble of related activities that contributes to the functioning of *efficient and sustainable* electricity supply".

Deriving from the SES objectives identified in chapter 2, this thesis poses that the technology component of SES entails three main technical functionalities. Firstly, flexibility technologies, which enable adjusting generation or load; secondly data

304. See chapter 2, section 3.1 "Technology Component: Smart Electricity System Objectives".
305. Briefly recalling, the following objectives were identified: improving energy efficiency, integrating RES, maintaining grid resilience, and integrating system users. The objectives are to a large extent interdependent and cannot be seen in isolation.
306. Hamilcar Knops, *A Functional Legal Design for Reliable Electricity Supply – How Technology Affects Law* (Energy & Law Series 6 Intersentia 2008), 79.

on the availability and needs of those flexibilities; and thirdly information and communication technologies (ICT) facilitating the data exchange on flexibilities and related prices in real-time among system users and between system users and system operators. Subsequently, system users are incentivised to react on the basis of the data and thereby contribute to system operations. SES thus facilitate a convergence of those realms which ideally enables a real-time cost-reflective electricity consumption, generation, and grid usage of every system user. Chapter 2 introduced this as "system user centricity".[307] The following three sections outline the main technical functionalities. This section concludes by identifying that SES imply technology convergence of those functionalities.

2.1.1 Flexibility Technologies

Merely increasing the amount of RES connected to the grid will not lead to the desired low-carbon electricity sector. As explained in chapter 2, it is equally important to use the variable sources *efficiently*.[308] Otherwise the generation of RES generation will remain to a large extent unused and even exacerbate the need for costly grid expansions and balancing power of conventional, fossil energy sources. Making the most optimal use of variable RES requires flexible consumption and use of the grid capacity. Flexibility can functionally be defined as *"the ability of a power system to maintain continuous service in the face of rapid and large swings in supply or demand."*[309] The ability to do so is closely related to the core technical features of the electricity system explained in chapter 1, maintaining frequency and voltage. *"From the electricity system point of view, flexibility relates closely to grid frequency and voltage control, delivery uncertainty and variability and power ramping rates."*[310] SES aim to enhance flexibility by including the demand-side in supply chain as an active component in order to efficiently match variable supply. "Active component" means that consumption also follows generation, which becomes paramount in the context of variable RES.[311]

Several technologies exist which enhance flexibility in the electricity system, they can be summarised under the term "demand-side response" (DSR)[312] which can be generally categorised in two types. Firstly, storage facilities can capture excess peak generation

307. See chapter 2, section 3.1.4 "System User Centricity".
308. See chapter 2, section 3.1.1 "Energy Efficiency".
309. Ecofys, 'Flexibility Options in Electricity Systems', 2014, Berlin.
310. Peter Lund, Juuso Lindgren, Jani Mikkola, and Jyri Salpakari, 'Review of Energy System Flexibility Measures to Enable High Levels of Variable Renewable Electricity' (2015) 45 Renewable Energy and Sustainable Energy Reviews, 785-807, 787.
311. Georgios Papaefthymiou and Ken Dragoon, 'Towards 100% Renewable Energy Systems: Uncapping Power System Flexibility' (2016) 92 Energy Policy 69-82, 70.
312. Cherelle Eid, Paul Codani, Yannick Perez, Javier Reneses, and Rudi Hakvoort, 'Managing Electric Flexibility from Distributed Resources: A Review of Incentives for Market Design' (2016) 64 Renewable and Sustainable Energy Reviews 237-247, 238.

of RES and store it for a later moment of consumption.[313] Secondly, flexibility can also be enhanced by adjusting demand according to generation. The simplest way of doing so is by postponing consumption to a later moment in time, for example by means of what are called "smart home technologies" (SHT).[314] Refraining from consumption only works in times of low generation; storage can also capture excess generation and can subsequently provide electricity in times of low generation. This indicates that even though the functional purpose of flexibility remains the same, namely the ability to adjust, flexibility technologies have different qualities. Three attributes of flexibility determine its quality for application, *"its direction, its electrical composition in capacity or power, and its availability defined by starting time and duration."*[315] The direction of flexibility technologies describes whether the technology is able to provide extra load and extra generation capacity. As explained above, whereas storage provides both directions (power-to-power storage), refraining consumption only works in one direction. The capacity describes the ability of a technology in terms of kW/second. The availability of flexibility is time-related and describes the starting and ending moment in relation to the capacity. This also describes the reaction speed of the technology. In the most ideal case, flexibility technologies provide large amounts of capacity in both directions in a short timeframe. In this way, flexibility could capture high peaks or demands in the short term; the degree of flexibility, and thus the quality, is high. However, not all technologies can provide a high degree of flexibility in all three attributes and can therefore be utilised for different needs determined by time (ranging from seconds to seasons) and capacity.[316]

3

Flexibility is not an end in itself, but becomes an essential function for mitigating increasing system costs for balancing growing amounts of variable RES. A broad range of technologies which enable flexibility of different qualities exists.[317] Harnessing the

313. Paul Dodds and Seamus Garvey, 'The Role of Energy Storage in Low-Carbon Energy Systems' in Trevor Letcher (ed) *Storing Energy* (Elsevier 2016) 3-22, 5. Storage technologies include a wide array of technologies of different scales and purposes. This research does not distinguish between the different technologies and assumes their main functionality is to provide flexibility to the electricity system, which includes charging, storing, and discharging energy. Important to mention here is, that storage can also imply a change of energy carrier, as it is not confined to storing and also releasing electricity, examples are power-to-gas or power-to-heat technologies.
314. *"Smart home technologies (SHTs) comprise sensors, monitors, interfaces, appliances and devices networked together to enable automation as well as localised and remote control of the domestic environment. Controllable appliances and devices include heating and hot water systems (boilers, radiators), lighting, windows, curtains, garage doors, fridges, TVs, and washing machines"*. Charlie Wilson, Tom Hargreaves, and Richard Hauxwill-Baldwin, 'Benefits and Risks of Smart Home Technologies' (2017) 103 Energy Policy, 72-83, 72.
315. Cherelle Eid, Paul Codani, Yurong Cheng, Yannick Perez, and Rudi Hakvoort, 'Aggregation of Demand Side Flexibility in a Smart Grid: A Review for European Market Design' (2015) EEM15 – 12th International Conference on the European Energy Market, 20-22 May 2015 2.
316. Ecofys, 'Flexibility Options in Electricity Systems', 2014, Berlin.
317. Peter Lund, Juuso Lindgren, Jani Mikkola, and Jyri Salpakari, 'Review of Energy System Flexibility Measures to Enable High Levels of Variable Renewable Electricity' (2015) 45 Renewable Energy and Sustainable Energy Reviews, 785-807, 787.

various potentials of the technologies in the most optimal manner, meaning matching generation and consumption with the least energy losses, requires information about the availability and need for flexibilities. To this end, data on generation, load, and flexibilities needs to be collected and exchanged. The following two sections introduce data and communication networks and smart meters as technical functionalities of SES complementing flexibility technologies.

2.1.2 Data

Chapter 2 explained the importance of load forecasting, the calculation of loads which are to be served by the grid, for the long-term planning and the short-term operation of the electricity system. The chapter outlined that load forecasting is a highly complex task and even though various mathematical models and datasets are considered, a degree of uncertainty always remains. The chapter further related the task of load forecasting to the "electricity sector in flux", where increasing amounts of decentral generation, prosumption, and changing demand patterns even further complicate load forecasting.[318] This exacerbates the need for precise information on generation, loads, and flexibilities at distribution system level. Only when information on available capacities is compiled and coordinated, can the available flexibilities and the need for extra capacity efficiently be aligned. Therefore, data collection and coordination is a core functionality of SES as without compiling and sharing information on consumption, generation, and available capacities the technologies offering flexibility remain useless. It is the data and the coordination of data and eventually the response of system users to the data which essentially make the operation of the system *"smart"*.[319]

In order to make the system *smart*, the purpose of data on generation, load, and grid capacities is to establish a cost-reflective price on consumption and grid usage. Cost-reflective prices based on real-time data not only place a price on the actual use of electricity and the grid, but ideally also provide system users with price signals *"which incentivise efficient investment and operation of their own loads, storage, and distributed generation"*.[320] To this end, the SES data ideally entails information on twofold billing components, namely the commodity (electricity) and transport (capacity) charge (meaning EUR/kWh and EUR/kW), in real-time, and locally dependent with nodal pricing. Currently, the commodity price for electricity and transport capacity charges are at distribution system level usually invoiced on a flat-rate, locally independent,

318. See chapter 1, section 2.1 "Technical Requirements".
319. Yakubu Tsado, David Lund, and Kelum Gamagea, 'Resilient Communication for Smart Grid Ubiquitous Sensor Network: State of the Art and Prospects for Next Generation' (2015) 71 Computer Communications 34-49, 36.
320. Robert Passey, Navid Haghdadi, Anna Bruce, and Iain MacGill, 'Designing More Cost Reflective Electricity Network Tariffs with Demand Charges' (2017) 109 Energy Policy 642-649, 643.

annual basis. To incentivise system users via a price signal to adjust their system usage (production or consumption) according to available capacities, the pricing mechanism deployed by SES needs to be more nuanced, meaning geared towards rewarding system users for mitigating system costs or charging system users for inducing system costs. Therefore, the data in SES needs to entail the information on commodity and transport prices in real-time, locally dependent with nodal pricing. Real-time data would add a precise time component to signal system users when consumption is either more or less expensive.[321] Locally dependent pricing, referred to as nodal pricing, would add a precise location component, for identifying where system users induce or mitigate costs.[322] While this would improve the reflection of individual cost-causation of system users, and ideally incentivise more efficient electricity consumption and grid usage, this would also increases the complexity of pricing tremendously, compared to a yearly, flat-rate charge which is location independent.[323]

Using data to this end requires that the data fulfils specific quantities and qualities. Essentially, the question is, how many factors and how much information is needed for SES performance. As mentioned, the data needs to entail information about consumption, generation, and capacities in order to sophisticate system operation, enable "smart" system operation. Moreover, at least theoretically, the shorter the time intervals of data collection and exchange, the more precise, thus efficient, can the system be operated. This however is also subject to a state of perfect coordination of all connected system users and the system state. The vast amounts of sensitive data not only need to be compiled, but also processed, shared, utilised, and protected.[324] Logically, the amounts of data increase with more factors taken into consideration. The factors can range from simple consumption data, to smart device data, to instantaneous power data, and information on weather conditions and forecasts.[325] However, not only is the quantity of data relevant, but even more decisive for reliable and efficient SES operation is the quality of the data. Data can vary in quality, which essentially

3

321. Hunt Allcott, 'Rethinking Real-Time Electricity Pricing' (2011) 33 Resource and Energy Economics 820-842, 822.
322. Martin Weibelzahl, 'Nodal, Zonal, or Uniform Electricity Pricing: How to deal with Network Congestion' (2017) 11(2) Frontiers in Energy 210-232, 213.
323. Cherelle Eid, Elta Koliou, Mercedes Valles, Javier Reneses, and Rudi Hakvoort, 'Time-based Pricing and Electricity Demand-Response: Existing Barriers and Next Steps' (2016) 40 Utilities Policy 15-25, 20.
324. Houda Daki, Asmaa El Hannani, Abdelhak Aqqal, Abdelfattah Haidine, and Aziz Dahbi, 'Big Data Management in Smart Grid: Concepts, Requirements and Implementation' (2017) 4(13) Journal of Big Data 1-19, 10. Data collection and coordination also requires data protection for the sake of privacy concerns. However, the issue of data protection is not subject to this research. This issue is for example addressed by Jonida Milaj-Weishaar, *Surveillance with Non-Purpose Built Technology – Challenges for the Protection of the Right to Privacy in the European Union* (Dissertation University of Groningen, 2017) 121.
325. An example study of the Netherlands estimates the amount of data to easily reach the range of petabytes on a yearly basis. See Marco Aiello and Giuliano Pagani, 'The Smart Grid's Data Generating Potentials' (2014) Proceedings of the 2014 Federated Conference on Computer Science and Information Systems 9-16, 12.

influences the accuracy of system operation in terms of reliability and efficiency. Many definitions aim at capturing the concept of data quality, yet, there is no exhaustive understanding. Instead, data quality can be captured by various aspects as for example accuracy, integrity, consistency, availability, and timeliness.[326] Each of those aspects can vary to a large extent and influence the overall efficiency of SES. Specifying quantity and quality aspects is therefore essential for enabling SES. Most relevant is here the connection between the purpose of data exchanges (cost-reflective pricing dependent on generation and grid capacities) and the quantity and quality of data. The next section introduces the third technical functionality of SES, the technical means for transmitting and exchanging the data: communication networks and smart meters.

2.1.3 Communication Networks and Smart Meters

The purpose of communication networks is transmitting data on generation, consumption, and flexibilities among system users and between system users and system operators. In contrast to the electricity grid system, which usually includes one grid infrastructure, the electricity cables, communication networks include a variety of technologies. The most tangible distinction is between wired and wireless technologies for communication networks. Within each category several technologies unfold.[327] It is beyond the scope and purpose of this thesis to illustrate each of those technologies. Instead, it is relevant to highlight that each of those technologies has different advantages and disadvantages for different purposes for SES. This explains the complexity in making the right choice of technology for SES communication networks. Furthermore, this highlights the relevance of a technology functional approach by firstly understanding technical functionalities of SES and secondly deducing conclusions for the organisational component of SES.

Facilitating communication between system users in SES is essential for determining the dynamic prices on the basis of the current system state and for coordinating the system users. To this end, various communication networks are needed which fulfil different purposes for SES. These purposes include, for example, facilitating access for system users, enabling system state estimation and real-time control of the distribution grid, the interconnection of local area communication networks, and delivering large amounts of data collected to remote control centres over long distances.[328] The different

326. Wen Chen, Kaile Zhou, Shanlin Yang, and Cheng Wu, 'Data Quality of Electricity Consumption Data in a Smart Grid Environment' (2017) 75 Renewable and Sustainable Energy Reviews 98-105, 99.

327. Wired technologies include for example power line communications (PLC), optical communications, and digital subscriber lines (DSL), while wireless technologies include for example wireless personal area network (WPAN), wireless local area network (WLAN), 3G/4G cellular networks, and satellites.

328. Emilio Ancillotti, Raffaele Bruno, and Marco Conti, 'The Role of Communication Systems in Smart Grids: Architectures, Technical Solutions and Research Challenges' (2013) 36 Computer Communications 1665-1697, 1678.

purposes require different quality of service (QoS) requirements determining which communication technology needs to be deployed. QoS parameters can be distinguished in quantitative and qualitative measures.[329] The QoS requirements specify which exact technology is most suitable for a specific SES communications purpose. As mentioned above, this research does not assess each technology regarding the varying QoS, but emphasises the complexity in deploying communication network technologies for SES purposes. Here again, the value of a functional approach in sketching a SES along their main technical functionalities becomes clear as it is not the specific technology which is important but the purpose of a specific function. QoS of communication networks present an example of this approach.

An essential component for communication networks for SES are smart meters. Smart meters are necessary for collecting and communicating data via communication networks. They are installed at the premises of system users (consumer and producer, or prosumer) and, as general meters, serve the purpose of measuring electricity consumption for billing purposes. Whereas traditional meters work analogically in one direction measuring consumption, smart meters are digital meters *"equipped with two-way communication technologies"* which also enable the communication of generation, loads, and flexibilities.[330] Smart meters are necessary for system users to participate in SES, because they form so to say the "gateway" for system users to send and receive data on flexibilities and subsequent pricing. Only via this "gateway" can system users engage as market participants by offering their flexibility profile and benefit from dynamic pricing schemes. Essentially, the idea of SES is based upon the ability of system users to bring in their flexibilities in consumption and system use.

2.2 Synthesis: Convergence of Physical and Information Realms

Convergence of technologies describes the phenomenon when technological development leads to the integration of prior different technologies or tools. This subsequently leads to new functions which were originally provided by separate technologies and often determined separated service sectors. One of the most

329. Quantitative measures include for example latency (time between sending and receiving a signal), reliability (measure of error rate in transmission of signals), and data rate (measure of how much data can be transmitted per second). Qualitative measures include scalability (load scalability: ability to handle increasing amounts of data traffic; geographical scalability: ability to deploy network in wide range of sizes and configurations), interoperability (ability to connect different devices and networks), flexibility (ability to support SES services with different quantitative requirements), and security (resilience of the network against failures and attacks). These parameters are extracted from Sabine Erlinghagen, Bill Lichtensteiger, and Jochen Markard, 'Smart Meter Communication Standards in Europe – a Comparison' (2015) 43 Renewable and Sustainable Energy Reviews 1249-1262, 1250 and Emilio Ancillotti, Raffaele Bruno, and Marco Conti, 'The Role of Communication Systems in Smart Grids: Architectures, Technical Solutions and Research Challenges' (2013) 36 Computer Communications 1665-1697, 1678.
330. Sabine Erlinghagen, Bill Lichtensteiger, and Jochen Markard, 'Smart Meter Communication Standards in Europe – a Comparison' (2015) 43 Renewable and Sustainable Energy Reviews 1249-1262, 1250.

prominent and tangible examples is the emergence of smartphones. Nowadays, the phone function of a smartphone is just one out of several, as it also integrates the function of text messaging, agenda keeping, online browsing, and a plethora of customised applications. Convergence of technologies can have major implications for legislation as technologies and subsequent service provisions merge. An example which is discussed in more detail below in this chapter is the telecommunications sector.[331] In the telecommunications sector the technical development of digitisation enabled a complete overhaul of the sector by repealing the prior technical limitations of content transmission. Essentially, the technical development rendered existing legislation and regulatory approaches meaningless. On the basis of the above outlined technical functionalities of SES (flexibility technologies, data, and communication networks), this section concludes and argues that in combination these functionalities cause a convergence of current technologies and functions in the electricity sector. This leads to the following section which contrasts the rationale of the current legal framework of the electricity sector with SES *Utopia* (section 3).

SES functionalities also provide an example of converging technologies by linking flexibility technologies, such as storage technologies or SHTs, with the availability of data. Jointly, the above identified SES functionalities (section 2.1) facilitate *"*[…] *a physical synergy between the information and power distribution networks* […].[332] The demarcation between flexibility providers (system users, who could be consumers, producer, or prosumers) and entities possessing the relevant data is repealed by communication networks of SES. System users of SES can offer their flexibility profile, of various qualities, and receive data on the general system state and respective prices, and provide data of their individual usage. The combination of technologies harnessing flexibility and data exchanges allows system users to act and react in novel ways and relations in the electricity sector. Ideally, all system users, individually or in aggregated forms, are enabled to provide services for system operation and electricity supply by offering flexibilities in generation and load. Contemplating the convergence of flexibility technologies and ICT thoroughly leads to various implications for roles of incumbent actors and thus the entire organisation of the electricity sector as enshrined in the current legal framework. System users of SES are incentivised and enabled to engage in market transactions by including their flexibilities in generation, consumption, and system usage. This has profound implications for the legal framework.

331. Section 4.1 "Analogies from the Telecommunications Sector".
332. Fabio Clarizia, Daniele Gallo, Carmine Landi, Mario Luiso, and Raffaele Rinaldi, 'Smart Metering Systems for Smart Grid Management' (2016) Instrumentation and Measurement Technology Conference Proceedings, Institute of Electrical and Electronics Engineers, 23 – 26 May 2016.

This section outlined the technology component of SES along the three main technical functionalities flexibility technologies, data, and communication networks and smart meters. This final section poses that those technologies cannot be seen in isolation, as the convergence of those functionalities is inherent to SES. This convergence merges prior clearly separate functionalities of the electricity system and thereby changes the technology component of the electricity system. Subsequently, this requires identifying consequences for the organisational setting of the electricity sector, and more specifically, the legal framework. In order to identify limitations of the current legal framework of the electricity sector for SES, the following section contrasts the rationale of the current legal framework with the technology component of SES.

3. CURRENT RATIONALE OF THE LEGAL FRAMEWORK V *SMART ELECTRICITY SYSTEM UTOPIA*

The above outlined blueprint of SES reveals that the technical functionalities of SES needs an organisational setting which facilitates and incentivises the efficient use of flexibilities in generation and consumption at all levels of the electricity supply chain. Identifying the limitations of the current legal framework for the above outlined SES blueprint requires understanding the different rationales of the system settings. The underlying rationales are enabling specific system settings. This thesis argues, that SES follow a different rationale necessarily leading to a different system setting which needs to be enabled and incentivised by the legal framework of the electricity sector. This section highlights the difference in the rationales. Subsequently, this chapter establishes theoretical groundwork for developing a legal framework for SES (section 4 and 5).

Chapter 1 outlined the evolution of the electricity sector, how technical development facilitated the emergence of large generation of electricity which can be transported over long distances, the high voltage transmission system, to the distribution system which forwards the electricity to the points of final consumption, the loads. This setting is often referred to as "top-down" electricity supply chain, where the electricity flows from generation unidirectional towards the consumers. The current rationale of the legal framework of the electricity sector is explicitly adapted to the "top-down" supply chain of the sector, which allocates main coordinating responsibilities to the transmission system level.[333] The legal framework further shaped the stetting of the sector according to two main objectives, namely liberalisation and RES targets. Here, the underlying rationale was improving overall economic welfare by means of competitive markets

333. See chapter 2, section 2.2 "Organisational Component: The Triangle of EU Electricity Sector Policy Goals".

in generation and supply of electricity and mitigating climate change by emission reductions from the electricity sector and improving fuel independency from third states.[334] The liberalisation of the electricity sector requires separating any potential market activity from the network. The legal framework assigns actors and tasks according to this setting. The actors are generators, system operators, suppliers, and consumers. Essentially, the system operators and the supply companies are the intermediating entities by physically and commercially connecting generation and consumption. The rationale of the current legal framework is thus motivated by two main factors: the technical "top-down" setting and the liberalisation which requires distinguishing between market and network tasks and subsequent actors.[335] This rationale explains the exact demarcation of tasks between actors in the legal framework. This setting is challenged by "the electricity sector in flux", characterised by increasing amounts of decentral generation, prosumption, and changing demand patters. Chapter 2 outlined that it becomes more difficult to ensure the main policy objectives in the electricity sector, leading to the "policy objective trilemma" and the challenge to maintain the technical integrity of the electricity system.[336] While SES provide technical solutions, their implementation needs to be facilitated by a legal framework which is based on a different rationale.

The rationale of a legal framework for SES can neither be based on a technical "top-down" setting, nor on an organisational setting which distinguishes between actors as established by the current legal framework The core technical functionality of SES is characterised by the convergence of flexibility technologies and ICT and data which, ideally, enables all system users to use electricity and the grid infrastructure in a real-time cost-reflective manner.[337] Currently, in line with the "top-down" setting", the legal framework focuses on large scale generation and the transmission system level, while the consumers and the distribution grid level remain practically idle in contributing to system flexibilities.[338] However, increasing the share of variable RES in the electricity system requires activating more flexibility sources at all levels of the supply chain.[339] The potential of demand-side flexibility is assessed as very high across Europe.[340] Harnessing

334. See chapter 1, section 3.1 "Liberalisation" and section 3.2 "Climate Change Mitigation".
335. See chapter 1, section 3. "Revolution 1.0 – Shaping the Electricity Sector".
336. See chapter 2, section 2 "Under Pressure: Grid Capacity and Policy Goals".
337. Section 2.2 "Synthesis: Convergence of Physical and Information Realms".
338. Kaisa Huhta, 'Prioritising Energy Efficiency and Demand Side Measures over Capacity Mechanisms under EU Energy Law' (2017) 35(1) Journal of Energy & Natural Resources 7-24, 21.
339. Goran Strbac, 'Demand Side Management: Benefits and Challenges' (2008) 36 Energy Policy 4419–4426, 4422.
340. A study determines an amount of 93 gigawatt (GW) hourly average for load reduction (delaying or shedding) and 247 GW for load increase (advancing demand to an earlier time). The study extends beyond member states of the European Union as it includes 40 countries in Europe. The study includes demand response potential from industry, tertiary sector, and residential consumers. See Hans Gils, 'Assessment of Theoretical Demand Response Potential in Europe' (2014) 67 Energy, 1-18, 6.

this potential requires the legal framework to enable and even more incentivise the deployment and operation of flexibility by system users at all levels of the supply chain. An ideal SES would thus depend on the contribution of flexibilities of all system users on all levels. Essentially, this implies repealing the "top-down" setting and also the existing actor categories, as SES centre around system users, and their different quality profiles in terms of flexibility potentials. This was introduced in chapter 2 as "system user centricity".[341] Inevitably, the rationale of the current legal framework becomes nugatory for SES, as the rationale of SES is based on the provision of flexibility which can be categorised in different qualities. The qualities describe different capabilities of system users to respond to the need to increase or decrease generation or load for system balancing. Their flexibility profile would also determine their commercial ability, as higher quality in flexibility would enable system users to reap greater benefits of dynamic prices. For example, a system users who possesses for example a home battery, an electric vehicle, SHTs, and solar panels can react with a much higher quality of flexibility (larger capacity and various timeframes, consumption and production) than a consumer who does not possess these technologies.[342] One possibility of increasing the potential of varying qualities of flexibility is by aggregating various system users with different flexibility profiles. Aggregation means pooling various sources to enhance their overall most optimal efficient usage.[343] Especially flexibility sources of lower quality, for example in terms of capacity and availability, could be utilised more optimally in aggregation models. This would enhance their potential to contribute to flexibility needs and subsequently improve overall efficiency of the electricity system.[344]

The rationale of SES is thus based on maximising flexibilities of different qualities of system users. Those considerations lead to the intermediate conclusion that a legal framework for SES cannot be based on the current definitions of actors, but needs to be based on functionalities of the system and subsequently on the contribution of the system users thereto and the coordination of system users. The following sections elaborate on further implications of this finding for the development of a legal framework which unlocks and coordinates these flexibilities.

341. Chapter 2, section 3.1.4 "System User Centricity".
342. This is further discussed in chapter 4, section 2.3.1.2 "Safety-Net for System Users".
343. Cherelle Eid, Paul Codani, Yurong Cheng, Yannick Perez, and Rudi Hakvoort, 'Aggregation of Demand Side Flexibility in a Smart Grid: A Review for European Market Design' (2015) EEM15 – 12th International Conference on the European Energy Market, 20-22 May 2015 2.
344. This is further discussed in chapter 4, section 2.1.1.2 "Aggregation of Demand-Side Flexibility".

4. THEORETICAL GROUNDWORK FOR A LEGAL FRAMEWORK FOR SMART ELECTRICITY SYSTEMS

The existing legal framework is geared towards a rationale which does not enable and incentivise the deployment and operation of SES functionalities at distribution grid level. Integrating specific technologies, for example electric vehicles as flexible storage option, under the rationale of the current legal framework will not lead to SES, but only to incomplete technology listings and subsequent provisions. Instead, this thesis argues that a legal framework for SES requires more fundamental changes. The preceding sections argued that the technical functionalities of SES facilitate convergence of technologies which renders the current actor typologies nugatory. Subsequently, this poses the following question: If not based on actors, which legal framework enables and incentivises SES? Answering this question, this section first draws analogies from the telecommunications sector, more specifically, EU telecommunication law, which also underwent significant legal reform as a response to major technological innovation.[345] Here, the concept of technology-neutral law emerged and provides relevant insights on how to regulate vast varieties of technologies which aim to serve the same purpose. In addition to technology-neutrality, however, the intermediate findings of this thesis also suggest that SES require a legal framework which is to a large extent actor-neutral and instead centres around the abilities of actors. From there, this section further expands the idea of regulating effects instead of specific technological by explaining the idea of goal-oriented regulation. Overall, this section provides the theoretical groundwork which is needed for developing a legal framework for SES which is not based on existing actors, but on technical functionalities of the system.

4.1 Analogies from the Telecommunications Sector

Developing a legal framework based on the technical functionalities of SES is a novel undertaking. Therefore, analogies can provide helpful starting points. Bearing in mind that drawing analogies always contains pitfalls and shortcomings, this section exhibits analogies from the telecommunication sector, more specifically, EU telecommunication law. This section firstly describes the technical innovation of digitisation in the EU telecommunication sector and secondly outlines the regulatory response to convergence of telecommunication technologies.

345. While communication networks are also part of SES, as explained in section 2.1.3 "Communication Networks and Smart Meters", in this section, the telecommunication sector rather serves as an analogy for reforming the legal framework in a network-bound sector as a response to technical development.

4.1.1 Digitisation and Convergence of Technologies

The telecommunication sector is also a network-bound sector, which means that any transmission of content depends on access to the relevant infrastructure. One important difference regarding the electricity sector is the great variety of technologies which can be used for transmitting data. While the electricity system contains mainly one grid which connects all system users, the conveyance of content in form of data in the ICT sector can be carried out by various technical means. However, this was not always the case as the sector was originally strictly divided in distinctive networks for specific services. For example, voice- and written content was transmitted via copper cables and sound and video content was transmitted via cable and satellites.

> "[…] *even though the sectors of broadcasting and telecommunications were comparable in the sense that they both conveyed information through various distribution means, there was no possibility to share or exchange either content or transmission means with each other. This situation was entirely caused by technical limitations of the networks at that time; it was technically impossible to interchange the various networks."*[346]

The legal framework was tailored to the technical setting and covered each sector separately. The systems were technically closed and therefore there was no need to capture the sector under one legal framework.[347]

The wide development of digitisation in content (pictures, sound, and writings) allowed a detachment of content from a specific transmission technology.[348] The way of data transmission became increasingly meaningless while bandwidth gained importance.

> *"Suddenly, different sorts of content could be transmitted over various networks, with as a consequence that traditional telecom companies would directly be competing with broadcasting companies and the newly emerging internet providers."*[349]

Certainly, this technical convergence of the sector completely changed the well-established market structures which were built upon the technical abilities of communication networks. Consequently, companies who were originally in different

346. Ilse van der Haar, *The Principle of Technological Neutrality: Connecting EC Network and Content Regulation* (Dissertation University of Tilburg, 2008), 31.
347. Pierre Larouche, 'Communications Convergence and Public Service Broadcasting' (2 November 2005) SSRN, 3.
348. Ian Walden, 'European Union Communications Law' in Ian Walden (ed) *Telecommunications Law and Regulation* (4th ed Oxford University Press 2012) 146.
349. Ilse van der Haar, 'Technology Neutrality: What Does It Entail?' (10 May 2007) SSRN, 4.

markets were competing, yet, the regulatory regime still distinguished between the different sectors. Inevitably, this resulted in unequal conditions for companies which led to the need of reconsidering the legal framework for the newly (e-)merged sector.[350]

4.1.2 Regulatory Response: Introducing Technology Neutrality

As a response to digitisation and the resulting convergence of technologies and thus sectors, the European Commission investigated those developments and impacts for the regulatory framework and presented their results in a Green Paper in 1997.[351] The assessment of convergence was positive as it was not only considered as a technical development but enabling *"new services and new ways of doing business and of interacting with society"*.[352] The main conclusion revealed that the legal framework needed fundamental adjustments in order to unleash the potential of technical convergence. Instead of distinguishing clearly defined sectors, regulation would need to capture the variety of services, which are due to convergence not bound to a particular network (sector). That would mean that regulation needs to refrain from focusing on particular technologies in order to enable a level-playing field for similar services offered by different technological means. The findings of the Green Paper paved the way towards the concept of technology neutrality as the regulatory approach for the ICT sector. However, technology neutrality was not yet explicitly identified as a possible regulatory approach, as the Green Paper mainly identified developments and regulatory obstacles. Still, it was indicated as an idea to be incorporated in regulation, which anticipated being applicable to the newly merging and emerging sector.[353]

Based on their findings, the European Commission published a Communication for the review of regulation for the communications sector in 1999.[354] Here, the concept of technology neutrality is officially mentioned and mentioned as one of five regulatory principles for future ICT sector regulation. Technology-neutrality is defined as follows:

> *"future regulation should* […] *aim to be technology neutral, i.e. not to impose nor discriminate in favour of, the use of a particular type of technology, but to ensure that the same service is regulated in an equivalent manner, irrespective of the means by which it is delivered"*.[355]

350. Ilse van der Haar, 'Technology Neutrality: What does it entail?' (10 May 2007) SSRN, 4.
351. Commission of the EC "Green Paper on the Convergence of the Telecommunications, Media and Information Sectors, and the Implications for Regulation. Towards an Information Society Approach", COM(97)623 (December 3, 1997). In the following Green Paper on Convergence.
352. Green Paper on Convergence ii.
353. Green Paper on Convergence 21.
354. Commission of the EC "Towards a new framework for Electronic Communications Infrastructure and Associated Services. The 1999 Communications Review" COM(1999)539 (November 10 1999).
355. Idem vi.

Relevant to emphasise is that technology neutrality is clearly categorised as a regulatory principle, which extends beyond the definition as a policy objective. That entails that it forms a guiding concept for the design of the legal framework of the sector.

In contrast to the legal framework of the telecommunication sector which distinguished the different sectors based on the technical capabilities, a new legal framework entered into force in 2002 which included four main Directives.[356] The Framework Directive clearly relates the regulatory reform to convergence of technologies by stating that

> *"the convergence of the telecommunications, media and information technology sectors means all transmission networks and services should be covered by a single regulatory framework".*[357]

This is further implemented by the wide definition of "electronic communications network" and "electronic communication service".[358] Both definitions aim at including all technologies and thereby establish a largely technology-neutral framework for the conveyance of electronic communications.

ICT includes a wide range of different technologies which partly could fulfil the same functions and therefore, for the sake of a competitive market, should be subject to the same legal framework. *"This principle* [technology neutrality] *sets the focus of regulation on the features of a particular type of service supplied to customers rather than on the technical means or type of technology used for its provision"*.[359] The core idea of technology neutrality in law can thus be summarised, and simplified as regulation which does not favour one technology over others. Technology neutrality is however not limited to the ICT sector. The contrary is the case: *"*[…] *note that any type of legislation is in fact technologically specific, since our environment is always technologically mediated."*[360] The rationale why technology-neutral law is implemented can however differ and requires a thorough understanding of the sector, more specifically the technical functions, to which it applies.

---

356. Framework Directive 2002/21/EC, Authorisation Directive 2002/20/EC, Universal Service Directive 2002/22/EC, Access Directive 2002/19/EC.
357. Recital 5 Framework Directive 2002/21/EC.
358. For example, art. 2(a) of the Framework Directive defines *"electronic communications network' means transmission systems and, where applicable, switching or routing equipment and other resources which permit the conveyance of signals by wire, by radio, by optical or by other electromagnetic means, including satellite networks, fixed (circuit- and packet-switched, including Internet) and mobile terrestrial networks, electricity cable systems, to the extent that they are used for the purpose of transmitting"*.
359. Milena Stoyanova *Competition Problems in Liberalized Telecommunications – Regulatory Solutions to Promote Effective Competition* (Kluwer Law International BV 2008) 30.
360. Mireille Hildebrandt and Laura Tielemans, 'Data Protection by Design and Technology Neutral Law' (2013) 29 Computer Law & Security Review 509-521, 509.

For this research the idea of technology-neutral regulation provides relevant insights as SES also imply convergence of technologies leading to merged functionalities which are currently technically and regulatory separated. Moreover, and a pivotal argument for technology neutrality, the variety of flexibility technologies makes it impossible to establish exhaustive technology specific regulation. As mentioned, the quality attributes of flexibility are decisive, not the technology itself. However, technology-neutral regulation is often criticised for reducing legal certainty as it abstracts away from specific technological means. The following section assesses this claim and further proposes a solution for alleviating it by embedding technology-neutrality in a meaningful context.

4.2 Technology Neutrality and Legal Certainty: A Trade-Off?

This section anticipates one widely discussed claim, namely that technology neutrality reduces legal certainty. This is based on the argument that legislation which abstracts from technologies remains vague and hence does not provide legal certainty. Assessing this claim and its validity requires identifying the broader rationale behind technology neutrality in more detail. This section thus outlines the reasons why technology-neutral law is implemented and relates those reasons to the quest for maintaining legal certainty.

Existing research establishes three main categories why technology-neutral law is implemented.[361] The first category relates to the *purpose of regulation*, stating that regulation should *"regulate functions and effects, not means"*. Related to this is the category of *consequences of regulation* meaning that technology-neutral law should facilitate *"functional equivalence"*. This means that law should focus on specific functions for determined outcomes. This is inherent to the first category, as regulating the effects would establish functional equivalence between different technologies. Furthermore, this entails that *"regulation should not unduly discriminate"*. "Unduly" refers to the possibility that there might be occasions when only a different treatment achieves an equivalent result. The last identified category is *legislative technique* and concerns "lasting law", meaning that developing regulation should be visionary to the extent that it copes with technological innovation over some time. This is also referred to as *"futureproofing regulation"*.[362] The quest to incorporate a technology-neutral approach

361. Bert-Jaap Koops, 'Should ICT Regulation be Technology-Neutral?' in Bert-Jaap Koops, Miriam Lips, Corien Prins, and Maurice Schellekens (eds) *Starting Points for ICT Regulation. Deconstructing Prevalent Policy One-Liners* (T.M.C. Asser Press IT & Law Series Vol. 9, The Hague 2006) 82.
362. Chris Reeds, 'Taking Sides on Technology Neutrality" (September 2007) 4(3) Script-ed, 263-284, 268.

in law is driven by technological development and changing technological options. As the example of convergence of technologies in the ICT sector proved, technical development strongly determines the organisational setting of a sector.

The explicit identification of categories of rationales is useful as they demonstrate that technology-neutral law can serve various purposes depending on the focal point. Moreover, the identification of the categories points out the need to carefully balance those different rationales as they are partly contradictive:

> "[…] *legislation that is too much focused on sustainability [sustainability refers here to "lasting law"] and hence abstracts very much away from technology will result in vague laws that provide little legal certainty.* […] *On the other hand, laws that focus too much on transparency by explicating technologies risk being inflexible and restricted, so that they provide little legal certainty with respect to related but somewhat different technologies".*[363]

Research on the application of technology-neutrality indicates that this trade-off is often not well understood and thus poorly implemented by the legislator.[364] The key challenge of technology-neutral law can thus be identified as striking the right balance between the level of technology abstraction and provision of legal certainty.

3

The following section further builds upon this challenge by linking technology-neutral law to what is referred to as goal-oriented regulation or also principle-based regulation. As mentioned, technology-neutral law only can become meaningful if it is directed towards a specific purpose. Goal-oriented regulation offers a technique for embedding technology-neutrality in a meaningful context.

4.3 Regulating Effects Instead of Means: The Idea of Goal-Oriented Regulation

Technology-neutral law offers a starting point for developing a legal framework for SES which is justified by the above identified reasons of convergence of technologies and a variety of potentially competing technologies and actors in SES. However, technology-neutral law alone does not provide the necessary context. As mentioned in the preceding section, *"technology-neutral regulation can serve various purposes depending on the focal point"*. Technology-neutral law on its own can thus not be meaningful as it needs to

363. Bert-Jaap Koops, 'Should ICT Regulation be Technology-Neutral?' in Bert-Jaap Koops, Miriam Lips, Corien Prins, and Maurice Schellekens (eds) *Starting Points for ICT Regulation. Deconstructing Prevalent Policy One-Liners* (T.M.C. Asser Press IT & Law Series Vol. 9, The Hague 2006) 97.

364. Brad Greenberg, 'Rethinking Technology Neutrality' (2015) 100(4) Minnesota Law Review 1495-1562, 1498 and Chris Reeds, 'Taking Sides on Technology Neutrality" (September 2007) 4(3) Script-ed 263-284, 265.

be directed towards a defined goal. This section introduces goal-oriented regulation as addition to technology-neutral law. Equally to technology-neutral law goal-oriented regulation aims at regulating effects instead of specific means and in addition defines the objectives and the governance processes of the concrete implementation. This section firstly describes the idea of goal-oriented regulation and secondly explains how goal-oriented regulation can be implemented in contrast to conventional rule-based regulation.

4.3.1 What is Goal-Oriented Regulation?

Goal-oriented regulation extends beyond technology-neutral law as it provides an overarching objective and establishes a governance process of implementation. Thereby it mitigates the identified key pitfalls of pure technology-neutral law as it sets a focal point and regulates governance of actors in the sector. Goal-oriented regulation can be described as

> *"*[…] *moving away from reliance on detailed, prescriptive rules and relying more on high-level, broadly stated rules or principles to set the standards by which regulated firms must conduct business".*[365]

Here, the connection to technology neutrality is clear, as goal-oriented regulation strives to set the outcome instead of the means of achieving that outcome. Relevant to mention is that the formulated goal can be rather abstract, but it can also be quite concrete in defining the goal to be achieved, for example by defining measurable outcomes.[366] This is relevant to understand as goal-oriented regulation is not to be confused with *"more vague rules"*.[367] The following quote explains and illustrates goal-regulation in contrast to rule-based regulation:

> *"*[…] *goal-regulation can be understood as a complete reversal of the traditional state of affairs, in which rules fix and prescribe a certain course of action to be followed in order to reach a certain goal. The examples that are usually analysed by philosophers of law are of this type. 'No dogs allowed', just as 'no vehicle in the park', or 'a will should be signed by three witnesses' typically prohibit or prescribe actions and these actions are means in order to reach an –often largely unspecified- goal. Whether the prohibition of dogs is meant to contribute to hygienic surroundings*

365. Julia Black, Martyn Hopper, and Christa Band, 'Making a Success of Principle-Based Regulation' (2007) 1 Law and Financial Markets Review, 191-206, 191.
366. Anne-Wietske Enequist, *From Abstract Goals to Concrete Rules: Regulating Nursing Home Care in Sweden and the Netherlands* (Dissertation University of Groningen 2015), 24.
367. Pauline Westerman, 'Arguing about Goals: The Diminishing Scope of Legal Reasoning' (2010) 24(2) Argumentation 211–226, 216.

> *or to the reduction of noise is therefore mainly a matter of interpretation. In goal-regulation that relationship is reversed. The goals are fixed and the means are left undetermined."*[368]

The advantages ascribed to goal-oriented regulation are as diverse as contested. Expected benefits can be summarised as providing flexibility, facilitating innovation, and improving competitiveness, while the disadvantages relate to uncertainty and predictability and allow the regulatee to *"backslide and get away with the minimum level of conduct possible"*.[369] As the means to achieve a specified outcome are not defined, the process of developing and implementing those means becomes much more crucial and eventually defines the success of the regulation. Moreover, this requires a dialogue between legislator and regulatees regarding the understanding of *"which conduct is required by the goals"*.[370] The reversed relation between goal and means, where the means are left undefined, shifts the significance to the process of developing those means by the relevant actors. Therefore, the next section explains how goal-regulation is implemented.

4.3.2 Implementation: From Central Rulemaking to Multilevel Governance

In contrast to rule-based regulation where the central legislator establishes specific means and the exact goal might be less clear, in goal-regulation the process of establishing the means is "outsourced" to actors in the targeted sector.[371] The process of developing rules to the respective goal is often referred to as *"concretisation process"*.[372] Essentially, this concretisation process is the governance of actors in the sector on different organisation levels, where *"each level not only represents a more local level of organisation, but also a more concrete version of the goal at hand"*.[373] In this way, a system of multilevel governance is established which is directed towards one goal, but can take different forms in means on "lower organisational levels". One important aspect in this setting is the relation between those different levels as "outsourcing" the process of concretisation does not imply that actors are autonomously engaging in self-regulation.

368. Pauline Westerman, 'Arguing about Goals: The Diminishing Scope of Legal Reasoning' (2010) 24(2) Argumentation 211–226, 216.
369. Julia Black, 'Forms and Paradoxes of Principle-Based Regulation' (2008) 3(4) Capital Markets Law Journal 425-457, 426.
370. Julia Black, Martyn Hopper, and Christa Band, 'Making a Success of Principle-Based Regulation' (2007) 1 Law and Financial Markets Review 191-206, 204.
371. Pauline Westerman, 'Who is Regulating the Self? Self-Regulation as Outsourced Rule-Making' (2010) 4(3) Legisprudence 225-241, 229.
372. Anne-Wietske Enequist, *From Abstract Goals to Concrete Rules: Regulating Nursing Home Care in Sweden and the Netherlands* (Dissertation University of Groningen 2015), 25.
373. Pauline Westerman illustrates this setting by sketching a schematic overview of the levels for the example of environmental law. See Pauline Westerman, 'Arguing about Goals: The Diminishing Scope of Legal Reasoning' (2010) 24(2) Argumentation 211–226, 215.

> *"Rather, the relation between legislator and norm-addressee can be analysed as one between a principal and an agent, in which P outsources the task of rulemaking to A. The A should draft its rules and laws, not for its own sake, but in order to achieve the aims aspired to by the principal. In order to control whether A fulfils that job adequately, the A has to report on the rules it drafted and the progress it made towards the imposed aims."*[374]

So, establishing a monitoring and reporting mechanism on advancing the goals is crucial. Such a mechanism would need to be in place for each organisational level. This eliminates the direct relationship between legislators and regulatees. Instead, this setting can be described as a *"regulatory regime"*, *where "rules are drafted, monitored, and enforced, and these tasks are not strictly separated"*.[375] Essential is then, who the actors are in the implementation process and at which level of governance they can play a role. Certainly, the setting of actors becomes much more intricate in multilevel governance in comparison to a setting in which a central legislator establishes all specified rules for implementation. Yet, a system with a central legislator establishing specified rules might also run the risk of oversimplifying instances which are not comparable. Arguably, detailed rules *"can lead to gaps, inconsistencies, rigidity, and are prone to 'creative compliance', to the need for constant adjustment to new situations and to the ratchet syndrome, as more rules are created to address new problems or close new gaps, creating more gaps and so on"*.[376] So, instead of establishing exhaustive rules, *"the centre of gravity shifts towards a regulation process"*, in which the actors of the sector are designing the rules on different organisational levels.[377] This development is also noticed in the energy sector:

> *"Regulation through cooperation is a characteristic of our times. There is not one single (and central) power, but there are rather several institutions, in both horizontal and vertical levels, sharing power. There is no longer only one instance which commands and controls, but rather several instances which must cooperate among themselves and whose role is not confined to the traditional limits of command-and-control-type regulation, as is the case with modern regulatory bodies. The cooperative regulators*

374. Pauline Westerman, 'Who is Regulating the Self? Self-Regulation as Outsourced Rule-Making' (2010) 4(3) Legisprudence 225-241, 241.
375. Pauline Westerman, 'Breaking the Circle: Goal-Legislation and the Need for Empirical Research' (2013) 1(3) The Theory and Practice of Legislation 395-414, 398.
376. Julia Black, Martyn Hopper, and Christa Band, 'Making a Success of Principle-Based Regulation' (2007) 1 Law and Financial Markets Review, 191-206, 193.
377. Anne-Wietske Enequist, *From Abstract Goals to Concrete Rules: Regulating Nursing Home Care in Sweden and the Netherlands* (Dissertation University of Groningen 2015), 27.

are expected nowadays to deploy a great variety of regulatory techniques, which, in turn, are not exclusively, nor mainly, of a coercive nature, but rather of a facilitative and incentivizing character."[378]

A concrete example of how this is implemented is the development of network codes, where several actors at different governance levels are involved in the drafting and the adoption of the codes.[379] The following section further elaborates on the idea of a technology-neutral, goal-oriented legal framework for SES.

5. A TECHNOLOGY-NEUTRAL, GOAL-ORIENTED LEGAL FRAMEWORK FOR SMART ELECTRICITY SYSTEMS

The preceding two sections introduced two theoretical ideas of forms of regulation. Technology-neutral regulation is a way of establishing a level-playing field for different technologies which serve the same outcome, goal-oriented regulation complements this idea by establishing the meaningful context (the goal) and the governance of actors in the sector. Those ideas provide valuable approaches regarding the aim of this chapter, establishing theoretical groundwork for a legal framework for SES which is based on the technical functions of the system instead of incumbent actors. Deducing from the sketch of the technology component of SES in section 2, section 3 argued that a legal framework for SES cannot be based on the current clear-cut actor typologies and actor-task couplings. The variety of technologies and actors which contribute to the functionalities of the system requires a legal framework which on the one hand is open for different forms of implementation, and on the other hand provides sufficient legal certainty for actors to invest and operate technologies. Both concerns are integrated in the above outlined theoretical ideas on technology-neutral- and goal-oriented regulation. However, those theoretical ideas need to be filled with content by applying them to the case of SES. The resulting question is, which aspects need to be regulated in a technology-neutral, goal-oriented legal framework for SES? To this end, the following subsection identifies main categories for a legal framework for SES.

378. Iñigo del Guayo and Johann- Christian Pielow, 'Electricity and Gas Infrastructure Planning in the European Union' in Martha Roggenkamp, Lila Barrera-Hernández, Donald Zillman, and Inigo Del Guayo (eds) *Energy Networks and the Law* (Oxford University Press, 2012) 363.
379. See chapter 1, section 3.1.3 "System Operation" and section 3.1.4 "Regulatory Oversight", and chapter 2, section 2.2.1 "Adequacy".

5.1 What is left to Regulate in a Legal Framework for Smart Electricity Systems?

The findings of this chapter suggest that a legal framework for SES needs to retreat from the current rationale of actor specific regulation and instead focus on technical functionalities and goals to be achieved. But what are then specific subjects of a legal framework for SES? Instead of identifying and providing points of adjustments to provisions in the current legal framework, this thesis aims at contemplating and analysing implications of technical functionalities of SES for a legal framework. This thesis does not analyse singled out technologies but aims at understanding the changes that come along with the technical functionalities in a more fundamental way. Essentially, the technical functionalities of SES change the role of system users, the electricity system, and interaction among system users *inter se* and system users and system operators. Along these three categories the following chapter identifies and analyses elements for a legal framework for SES (chapter 4). This section briefly introduces the categories in general.

In the current electricity sector setting system users are generally defined in two main categories, namely producers and consumers. Flexibility technologies, communication networks, and availability of real-time data on capacities in the system render them into market participants who are not distinguished by a predetermined category, but by their ability to react to rapidly changing prices (for example in minute intervals). Their ability to do so is determined by what was introduced as "flexibility profile of system users". Therefore, this thesis applies the term system users for all participants in SES, instead of distinguishing between consumers and producers. This claim and subsequent elements for a legal framework are elaborated in the following chapter.

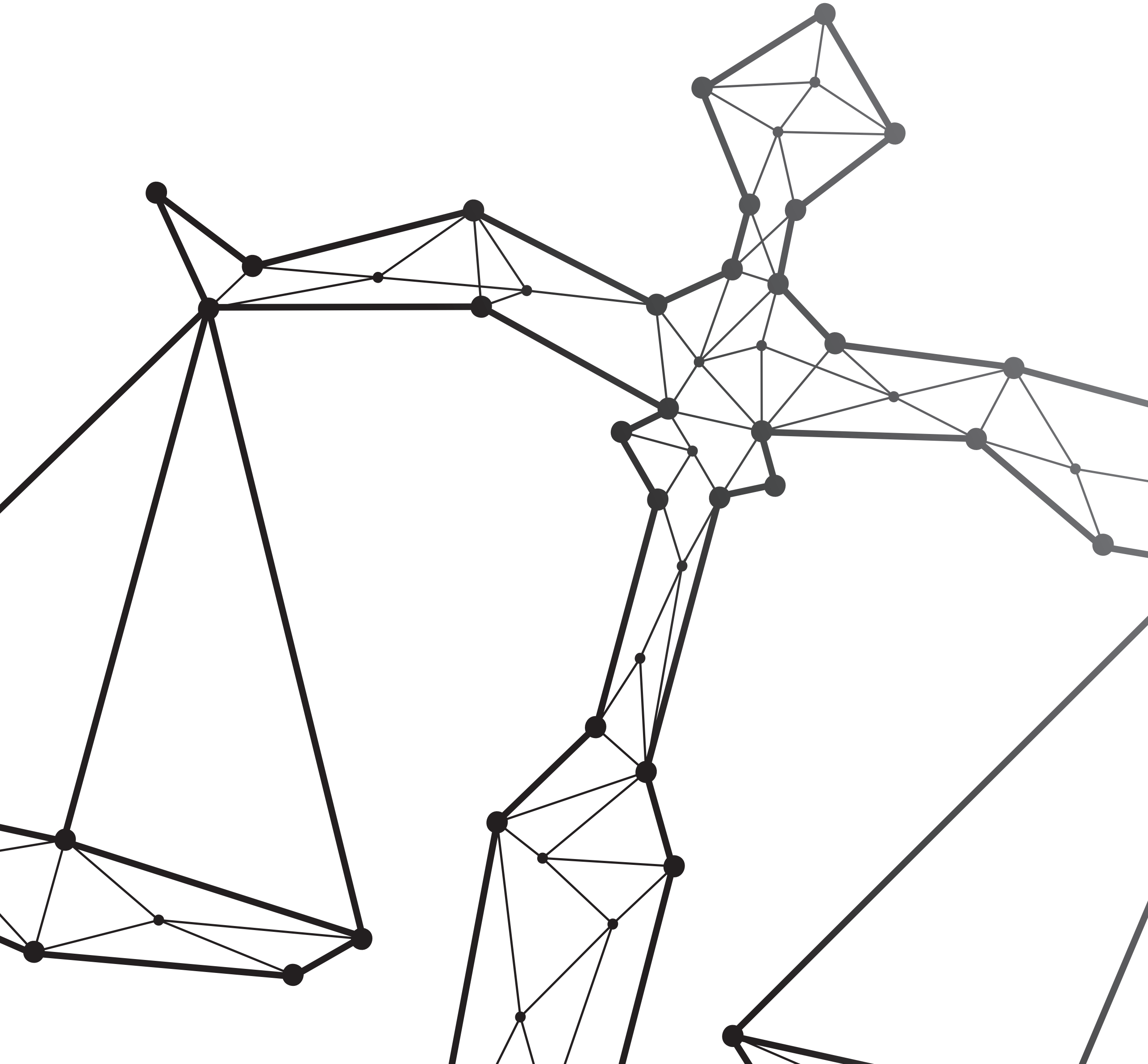
The current electricity system is understood to be the electricity grid infrastructure, the cables and grid assets from the point of production until the metering point of the consumers. The technical functionalities of SES extend the understanding of the electricity system beyond the grid assets in the following two ways: by adding communication networks for data exchanges to the system and by taking into account flexibility technologies behind the meter of system users. In this system, energy efficiency improvement is the core maxim for the operation by communicating capacities of all connected system users and devices. This also again explains the choice of the term SES over "smart grids" as introduced in the introduction chapter of this thesis.

Interactions in the current electricity sector are facilitated by suppliers and system operators who connect producers and consumers. The tasks of system operators and suppliers are to a large extent based on information on generation and load profiles and forecasts. SES functionalities enable system users accessing this information and subsequently engaging in market transactions which are self-determined to a large extent. The technical functionalities of SES thus increase the number of actors who can engage in interactions and diversify the services by focusing on efficiency gains and thus flexibility of system users. The commercial abilities of system users are thus largely determined by their flexibility profile.

6. CONCLUSION

This thesis proposes a novel way of developing a legal framework which enables and incentivises SES. Instead of building on the existing rationale of the current legal framework, this chapter argued that the technical functionalities of SES cannot be captured by exhaustive rule-based regulation, but that a legal framework for SES needs to be based on technology-neutral and goal-oriented regulation.

Applying such a legal framework requires focusing on the technical functionalities instead of specific singled out technologies and existing actors. Generally, the technical functionalities of SES sophisticate the technical component of the electricity system and also change the economic component by shifting the rationale towards engaging all system users and devices as potential flexibility sources. These modified components are interdependent and determine the role of system users, the electricity system, and interactions. This raises legal issues which are identified and analysed in more detail in the following chapter.



CHAPTER 4:

FROM UTOPIA TO REALITY: A LEGAL FRAMEWORK FOR SMART ELECTRICITY SYSTEMS

1. INTRODUCTION

This chapter applies the previously established finding that the development of a legal framework has to be based on the functionalities of SES. The three main functionalities of SES were identified as “flexibility technologies”, “communication networks”, and “data”.[380] Those functionalities profoundly change the notion and role of system users, the electricity system, and interactions as established by the current legal framework. This chapter identifies those changes and based thereon identifies key issues for a legal framework for SES, reveals the main obstacles for SES under the current legal framework, and relates the findings to recent (and ongoing) EU legislative developments. This further leads to the conclusive chapter of this thesis which derives findings regarding a legal framework which enables and incentivises SES.

The preceding chapter also identified the differences in rationales between the current legal framework of the electricity sector and a legal framework for SES. The chapter argued that the rationales of the legal framework are based on the technical and the economic component of the electricity system. SES enhance the technical and the economic component. The technical component is modified by sophisticating the electricity system with communication networks and smart metering systems. The economic component is rendered by integrating flexibilities of demand-side flexibilities which enables consumers to develop into active market participantsat distribution grid level. The technical and the economic component are strongly intertwined and jointly determine the role of system users, the electricity system, and interactions in SES which need to be facilitated by the legal framework. Along those categories (system users, system, and interactions), this chapter identifies key issues for a legal framework for SES. The chapter argues that a legal framework organised along system users, the system, and interactions needs to incorporate three main points:

1. Incentivise system users to invest in- and use flexibility technologies
2. Establish efficiency gains as the core maxim for system operations in distribution network tariff structures and access provisions, and
3. Enable interactions based on data autonomy among system users *inter se* and between system users and system operators and provide a safety-net for ensuring reliable electricity supply and distribution.

In this way, this chapter includes and applies all essential findings from the previous chapters. Chapter 1 established the general setting of the electricity sector by

380. See chapter 3, section 2.1 “Technology Component”.

introducing the approach to distinguish between the technology component and the organisational component of the sector and outlined the current legal framework of the electricity sector. Chapter 2 identified the main EU policy goals in the electricity sector and on basis thereof deduced the quest for SES. Chapter 3 identified the main functionalities of SES and argued that a legal framework for SES needs to be goal-oriented and technology-neutral. This chapter applies those findings by developing a legal framework closely connected to the technical functionalities of SES in a technology-neutral and goal-oriented fashion. Thereby, this chapter forms the last step in the envisaged feedback-loop from the objectives ascribed to SES (chapter 2), via the technical functionalities of SES (chapter 3), to the development of a legal framework (present chapter 4). Finally, the development of a legal framework provides a basis for drawing recommendations how to actually adjust the current legal framework as a first step towards the realisation of SES.

In order to accomplish the shift "from utopia to reality" as the title suggests, this chapter investigates whether the findings of the development of a legal framework for SES of this thesis correspond with current efforts to reform EU electricity sector legislation. To this end, this chapter firstly identifies the main elements of a legal framework which is based on SES functionalities and secondly analyses recent legislative developments on EU level aiming to reform the legal framework of the electricity sector, the *"Clean Energy Package for All Europeans"* (CEP),[381] and especially the recast electricity market directive and the recently adopted RES directive.[382] This leads to the conclusion of this thesis which identifies the key points for a legal framework which enables and incentivises SES.

This chapter unfolds in the following main sections: Section 2 is the core section as it identifies the main topics for a legal framework for SES on the basis of SES functionalities along the role of system users, the electricity system, and interactions in SES. Building thereon, section 3 reveals the main obstacles for SES under the current legal framework. Section 4 discusses recent legislative developments at the EU level regarding the CEP which aims at facilitating a *"clean, consumer-centred energy transition"*. The chapter concludes that even though the CEP aims at fostering an electricity sector which is based on decentral small-scale renewable energy technologies, the legislative proposal is not based on technical functionalities but remains based on the current rationale. This leads to the conclusion of this thesis which derives the main findings of this thesis for a legal framework which enables and incentivises SES.

381. EU Commission, 'Clean Energy Package for All Europeans' (30 November 2016).
382. Commission of the EU, Proposal for a Directive on Common Rules for the Internal Market in Electricity, COM (2016) 864 final/2 (30.11.2016).

2. A LEGAL FRAMEWORK FOR SMART ELECTRICITY SYSTEMS BASED ON FUNCTIONALITIES

The preceding chapter established theoretical groundwork for the development of a legal framework for SES. The chapter argued that the functionalities of SES cannot be captured by exhaustive rule-based regulation, but that a legal framework for SES needs to be based on technology-neutral, goal-oriented regulation. Based on those premises, this part of this thesis develops a legal framework for SES on basis of the main identified technical functionalities of SES, namely: flexibility technologies, communication networks, and data (information access).[383] Those functionalities change the role of system users, the electricity system, and the interactions as established by the current legal framework. Being aware that the chosen categories are strongly interconnected, the following three sections develop a legal framework for SES along the changing role of system users, the electricity system, and interactions.

2.1 System Users as Flexibility Sources

One of the core functionalities of SES is utilising flexibility of all system users, especially including system users connected to the distribution grid, in order to exploit energy resources and grid capacity in an efficient manner.[384]

> *"Minimising total system costs at high shares of VRES-E* [variable-renewable energy sources-electricity] *requires a strategic approach to adapting and transforming the energy system as a whole. To meet this goal, all countries where VRES-E is becoming a mainstream part of the electricity mix should make better use of existing flexibility by optimising system and market operations."*[385]

Harnessing this flexibility requires the legal framework to incentivise and coordinate system users to invest in – and use flexibility technologies. This section describes the changing role of system users in SES and discusses how a legal framework can facilitate their role as "flexibility providers".

The electricity system has been designed and built along the goal to secure supply at all times at affordable costs.[386] Accordingly, the generation and transport capacities need to be adequate to serve demand continuously. This setting is challenged by the aim to

383. See chapter 3, section 2.1 "Technology Component".
384. See chapter 3, section 2.1.1 "Flexibility Technologies".
385. Joan Batalla-Bejerano and Elisa Trujillo-Baute, 'Impacts of Intermittent Renewable Generation on Electricity System Costs' (2016) 94 Energy Policy 411-420, 418.
386. See chapter 2, section 2.2 "Organisational Component: EU Policy Goals".

reduce GHG emissions and increase fuel independency from third states by integrating electricity generated on the basis of RES. Along with the aim to foster RES comes the goal to expand electrification, for example by increasing electric transportation, which, if based on RES, furthers the development of a low-carbon society. Both, the variability of RES and increasing and less predictable demand due to electrification, necessitate the activation of demand-flexibility of system users. Research reveals that demand-flexibility entails large potentials for reducing the need for extra generation and network capacities to cover peak demands.[387] In order to harness flexibilities of system users the idea of SES is to provide economic signals and incentives to system users to use or not use energy and grid capacity depending on generation peak- and off-peak periods and the availability of grid capacity. In this way, the idea of SES busts what is often referred to as the "copper-plate" scenario which assumes unlimited generation and transport capacity in electricity systems. Currently, this assumption is reflected in the prices for electricity and the network tariffs which are largely inflexible and expressed in a flat-rate, location-independent charge.[388] That the "copper-plate" scenario is a myth becomes increasingly evident with the integration of variable RES creating larger peak- and off-peak periods. Maintaining balance in the electricity grid under those fluctuating condition results in growing costs. These costs especially accrue to persons who cannot afford investing in RES generation and thus cannot reap financial rewards for generation. This indicates a social dimension of the promotion of RES generation which, if limited grid capacity is not taken into account, could result in a severe problem. One of the key functionalities of SES is to assign the exact costs of grid capacity usage to the persons (system users) who induced them and reward system users who mitigate these costs. In this way, the costs for electricity consumption and grid usage would not be based on estimations, but on individual dynamic costs which ideally incentivise system users to invest in flexibility technologies and use them by adjusting their consumption patterns.

As argued in chapter 3, harnessing flexibility, especially demand-side flexibility, changes the role of system users from clearly delineated actors such as "producers" or "consumers" to "flexibility providers" and even "system shapers" as their actions and reactions to economic signals and incentives influence the system as a whole. The current legal framework does not incentivise and coordinate the activation of demand-flexibility of system users at distribution grid level as it mainly developed along the goal to ensure adequate and affordable electricity supply continuously. The technical functionality

387. Hans Gils, 'Assessment of Theoretical Demand Response Potential in Europe' (2014) 64 Energy 1-18, 6.
388. Cherelle Eid, Elta Koliou, Mercedes Valles, Javier Reneses, and Rudi Hakvoort, 'Time-based Pricing and Electricity Demand-Response: Existing Barriers and Next Steps' (2016) 40 Utilities Policy 15-25, 19.

of SES “flexibility” requires a legal framework which incentivises system users to firstly invest in- and secondly use flexibility technologies according to economic signals which reflect efficiency gains in electricity generation and transportation.

2.1.1 Incentivising System Users to Invest in- and Use Flexibilities

Before system users can harness their flexibilities and engage in demand-response, they need to venture investments in flexibility technologies. Those could be for example storage technologies, which could include electric vehicles, and various smart home technologies (SHT).[389] In order to incentivise system users to engage in flexibility provision, a legal framework for SES needs to provide certainty by ensuring that those investments can be firstly undertaken, secondly recouped in a foreseeable time period, and thirdly lead to financial benefits after amortisation. In this way, the legal framework can establish incentives and safeguards for system users as flexibility providers in SES. This section outlines how the legal framework could facilitate those incentivises and safeguards by implementing dynamic pricing schemes in combination with demand-side flexibility aggregation.

2.1.1.1 Dynamic Pricing

Generally, pricing of electricity supply and transport entails two components, the energy component, expressed in the actually consumed kilowatt hours and the network tariff which is the charge for the use of the grid infrastructure.[390] While the former mentioned energy, or commodity, component is rather straight forward, the latter mentioned network tariff can be constructed in various ways (this is discussed further below in section 2.2.1.1).[391] Expectedly, in an electricity sector with a large proportion of generation on the basis of RES, both components become increasingly interdependent which requires utilising flexibility for minimising system costs.[392] One of the core functions of SES is to financially incentivise system users to adjust their electricity and system use to maximise efficiency in electricity supply and transport.[393] In order to enable those financial incentives, the legal framework of the electricity sector needs to incorporate cost-reflective prices for the use of energy and grid capacity. “Cost-reflective” means a price which reflects the actual value of electricity supply and transport at a

389. See chapter 4, section 2.1.1 “Flexibility Technologies”.
390. See chapter 2, section 2.2.2 “Affordability”.
391. Vivek Sakhrani and John Parson, ‘Electricity Network Tariff Architectures. A Comparison of four OECD Countries’ (2010) MIT Centre for Energy and Environmental Policy Research, 10 and Michiel Nijhuis, Madeleine Gibescu, and Sjef Cobben, ‘Analysis of Reflectivity and Predictability of Electricity Network Tariff Structures for Household Consumers’ (2017) 109 Energy Policy 109 631-641, 634.
392. Joan Batalla-Bejerano and Elisa Trujillo-Baute, ‘Impacts of Intermittent Renewable Generation on Electricity System Costs’ (2016) 94 Energy Policy 411-420, 418.
393. Michael Schreiber, Martin Wainstein, Patrick Hochloff, and Roger Dargaville, ‘Flexible Electricity Tariffs: Power and Energy Price Signals Designed for a Smarter Grid’ (2015) 93 Energy 2568-2581, 2570.

particular moment in time and stands in contrast to locational-independent, flat rate-based pricing mechanism.[394] "Cost-reflective" pricing mechanisms are often referred to as "dynamic pricing" as they dynamically reflect the real-time individualised costs of electricity supply and distribution. However, in the current EU electricity sector, the possibility to offer demand flexibility depending on dynamic prices is mostly directed towards large consumers, for example industries with high electricity consumption.[395] Flexibilities of small consumers located at the distribution grid level remain largely unused.[396]

The implementation of dynamic pricing can take various forms and is a prerequisite for demand-side response (DSR), describing the response by system users to dynamic electricity prices and network tariffs.[397] A large variety of pricing mechanisms exists, which all involve a specific degree of price-volatility and a rewarding system for price-responsiveness of system users. Usually, with a higher volatility of the price reward risk increases, while with a less volatile or static price, the reward and the risk are lower.[398] The legal framework for SES needs to balance between rewards and risks in order to incentivise system users to invest in- and use flexibility technologies. The distinguishing feature of DSR schemes is the remuneration mechanism for the adjusted consumption. Two general categories of DSR schemes exist, namely incentive-based schemes and price-based schemes (sometimes also referred to as "explicit" and "implicit" DSR schemes).[399] Both categories can be further subdivided in specific rewarding mechanisms.[400] The main difference between incentive- and price-based mechanisms is that while in incentivise-based schemes system users receive a direct and incidental financial reward for trading their flexibility in consumption, in price-based mechanisms system users are always subject to dynamic electricity prices as provided in their supply contract.[401] Both sorts of schemes could also be complementary which would be determined in the electricity supply and delivery contract.

394. Robert Passey, Navid Haghdadi, Anna Bruce, and Iain MacGill, 'Designing more Cost-Reflective Electricity Network Tariffs with Demand Charges' (2017) 109 Energy Policy 642-649, 643.
395. Commission of the EU, Joint Research Centre, 'Demand Response Status in EU Member States' (2016) 127.
396. Hans Gils, 'Assessment of Theoretical Demand Response Potential in Europe' (2014) 67 Energy 1-18, 6.
397. Mohammed Albadi and Ehab El-Saadany 'A Summary of Demand Response in Electricity Markets' (2008) 78 Electric Power Systems Research, 1989–1996, 1990.
398. Grayson Heffner, 'Smart Grid – Smart Customer Policy Needs' (2011) International Energy Agency 517-524, 520.
399. Commission of the EU, Joint Research Centre (Paolo Bertoldi, Paolo Zancanella, Benigna Boza-Kiss), 'Demand Response Status in EU Member States' (2016) 2.
400. Incentive-based mechanisms include for example interruptible programs, demand bidding, and ancillary services. Price-based mechanisms include time-of-use pricing such as critical-peak pricing, and real-time pricing.
401. Mohammed Albadi and Ehab El-Saadany 'A Summary of Demand Response in Electricity Markets' (2008) 78 Electric Power Systems Research, 1989–1996, 1990.

The most exact, in terms of individual cost-reflectivity, price-based DSR scheme is real-time pricing (RTP).[402] RTP implies changing prices in very short time frames, for example in minute intervals. With a high level of precision in the pricing components, system users would be able to reap the benefits of low prices and also pay for individualised induced costs close to real-time. However, this also bears the risk that the rapid fluctuations increase uncertainties and therefore pose an obstacle to invest in flexibility technologies. The legal framework for SES aiming to incentivise system users to invest in- and use flexibilities would thus need to establish precise dynamic pricing schemes as default pricing mechanism, but also ensure stability for recouping investments. This requires balancing between the aim to improve cost-reflectivity and investment certainty in order to incentivise system users to invest in- and use flexibility technologies. One possible measure to strike this balance could be to aggregate demand-side flexibility potentials in order to improve the overall flexibility potential of system users and mitigate the impact of highly fluctuating prices for individual system users. This could be of special relevance for small consumers who are limited in their abilities to install larger scale flexibility technologies. The following section introduces aggregation as measure to mitigate fluctuations of dynamic pricing and facilitate safeguards for system users as flexibility providers in SES.

2.1.1.2 Aggregation of Demand-Side Flexibilities

Aggregation is the idea of pooling demand-side flexibilities of system users and thereby enhancing their position in trading flexibility in load (consumption) and, if small scale RES generation is installed, possibly also in generation.[403] In this way, aggregation substitutes the need for system users to take individual decisions on long-term investments or short-term consumption adjustments. As stated above, aggregation can thus be a way of mitigating uncertainties in investments and consumption patterns of system users. Generally, the idea of aggregation is not new, as in the current electricity sector setting the load-profiles of consumers are aggregated by their suppliers. In this way, the suppliers take responsibility of the aggregated load-profiles and communicate the necessary capacities to the system operators. For residential consumers and small customers balancing responsibility is only undertaken in one-way, for the purpose to match generation with the loads. As outlined above (section 2.1), with increasing amounts of RES integrated in the electricity system, loads (demand) also need to follow generation. The idea of aggregators in SES is that loads can be aggregated for serving as flexibility sources for system operation. In that sense, aggregation is an organisational

402. Ahmad Faruqui, 'Arcturus: International Evidence on Dynamic Pricing' (2013) 26(7) The Electricity Journal 55-65, 57.

403. Cherelle Eid, Paul Codani, Yurong Chen, Yannick Perez, and Rudi Hakvoort, 'Aggregation of Demand Side Flexibility in a Smart Grid: A Review for European Market Design' EEM15 – 12th International Conference on the European Energy Market. 20-22 May 2015.

element for enhancing flexibility in the electricity system. Therefore, the legal framework needs to establish aggregation as a task in the electricity sector. Aggregators could function as commercial agents for system users who offer some flexibility but are yet hindered by uncertainties of investment recoupments or daily usage of flexibility sources. To this end, the legal framework for SES needs to define the role and tasks of aggregators in the electricity sector.

Aggregation of demand-side flexibilities to incentivise system users to engage in flexibility provision can take place at different organisational levels in the electricity supply chain. Aggregation of demand-side flexibility could for example be integrated in already existing structures and contractual relations. One example could be housing cooperations which install flexibility technologies (for example storage technologie or SHTs) in dwellings, flats, or building complexes and thereby aggregate the flexibility profiles of their residents. So, the task of aggregation could be undertaken by different actors.

Their role could be generally described as market intermediary, pooling system users and acting as their agents to maximise profit from bundled flexibility sources.[404] However, also the system users being aggregated need to fulfil a role as "aggregatees". They contract their ability and willingness to adjust their demand. Depending on the quality of their offered flexibility (capacity and timing)[405] they receive remuneration. In other words, a higher quality of flexibility improves the firmness of the commercial profile of the aggregator which again becomes a benefit for the aggregatees. This relation also requires establishing liabilities in case of non-compliance, for example if an "aggregatee" fails to deliver the contracted flexibility. As this would result in higher costs for the aggregator, non-compliance of aggregatees to deliver their contracted flexibility could for example be expressed in fines. While aggregation could thus function as an organisational measure to enhance overall flexibility and improve the commercial position of system users in flexibility provision, aggregation also brings about responsibilities for aggregatees to deliver.

A precondition for aggregation models is that aggregators have access to information on flexibility profiles of system users and are designated as transacting agents of system users.[406] This further connects to the next section which outlines the changing role of the

404. Xian He, Nico Keyaerts, Isabel Azevedo, Leonardo Meeus, Leigh Hancher, and Jean-Michel Glachant, 'How to Engage Consumers in Demand Response: A Contract Perspective' (2013) 27 Utilities Policy 108 – 122, 114.
405. See chapter 3, section 2.1.1 "Flexibility Technologies".
406. Cherelle Eid, Paul Codani, Yurong Chen, Yannick Perez, and Rudi Hakvoort, 'Aggregation of Demand Side Flexibility in a Smart Grid: A Review for European Market Design' EEM15 – 12th International Conference on the European Energy Market. 20-22 May 2015, 2.

electricity system as it is enhanced with ICT for SES purposes. Procuring flexibility to this end, for example from aggregators, needs to be incentivised by establishing efficiency gains as the core maxim for electricity system operation. Core to the idea of SES is that efficiency gains are not restricted to the cable infrastructure of the electricity grid, but can be extended behind the meter of system users, meaning everything connected to the grid. This is discussed in the following sections.

2.2 Electricity Systems and ICTs

In order to communicate and coordinate the flexibilities of system users, SES are electricity systems which are enhanced with ICTs. ICTs transmit the data (information) on flexibilities, energy resources, and grid capacity among system users, system operators, and possible third- intermediating parties such as aggregators (as introduced above). This extends the electricity system beyond the cable infrastructure and metering points as everything connected to the electricity system (generation, loads, and flexibilities thereof) influences the system and can be taken into consideration. This section describes the changing notion of the electricity system into SES and analyses why this changing notion requires the legal framework for SES to redefine the operational maxim of the electricity system towards efficiency gains.

As explained in chapter 1, the liberalisation efforts of the electricity sector resulted in gradually stricter division between network operational tasks and (potential) market activities.[407] Accordingly, the legal framework established the tasks of system operators. For the distribution grid, the DSOs are the responsible system operators. They possess the legal monopoly to maintain and operate the distribution system.[408] While the term "distribution system" is not defined, "distribution" is defined as *"the transport of electricity on high-voltage, medium-voltage and low-voltage distribution systems with a view to its delivery to customers, but does not include supply"*.[409] The distribution system would thus encompass the electricity infrastructure, cables for electricity distribution until the point of delivery, the meters of the customers. The understanding of the term electricity system in SES would need to extend beyond the cables distributing electricity until the metering points of customers. Ideally, everything connected to the electricity system, system users and devices, is part of the system as everything influences the system by being connected via ICT infrastructures. Essentially, the flexibilities of the system users and devices are the key resources for system operation, what was outlined

407. See chapter 1, section 3.1 "Liberalisation".
408. Art. 32(1) Directive 2009/72/EC.
409. Art. 2(5) Directive 2009/72/EC.

above as "demand-side flexibility". This, however, would also require re-establishing the task of system operation to consider the connected demand-side flexibilities as core contributors to "smart" system operation.

Chapter 3 concluded that a legal framework for SES needs to be based on SES functionalities. Therefore, this section does not depart from the actor-based approach by extending the tasks of the incumbent DSOs to SES functionalities. Instead, the following sections establish the maxim for system operation in SES, namely efficiency gains (*smart* operation). The legal framework can steer the maxim of system operation by establishing the network tariff methodologies, the revenue model for system operations, which would need to incorporate efficiency gains as core aim and by ensuring access for all system users to SES, the electricity system and also the necessary communications networks.

2.2.1 Efficiency Gains as Maxim for System Operations

In order to harness demand-side flexibilities, the core maxim of system operation needs to be determined as increasing efficiency gains by optimising grid usage. As indicated in the preceding section, ICT infrastructure of SES allows extending efficiency gains beyond the cable infrastructure by including all connected elements to the grid. This would, for example, also reduce the need for idly spinning balancing generation reserves. SES thus allow for a more holistic understanding of efficiency gains beyond the cable infrastructure of the grid. This could be facilitated by a legal framework establishing network tariff structures which incorporate efficiency gains as core goal for electricity system operation and ensuring access for system users to SES infrastructure as they become the resource for flexibilities and thus efficiency gains (see previous section).

2.2.1.1 "Smart" Distribution Network Tariff Structures

Due to the fact that the operation of the electricity system is a natural monopoly and the task of system operation is assigned to designated system operators, the remuneration for the operation needs to be based on regulated and approved tariff structures.[410] Generally, the aim is to avoid that system operators exploit their monopoly position and charge unreasonably high prices for system use and stop innovating their business. Network tariffs have thus a twofold function. They send signals to system users how to use the system (this was discussed above for the changing role of system users under the section 2.1.1.1 on "dynamic pricing") and they establish the allowed revenue for the

410. See chapter 2, section 2.2.2 "Affordability".

system operators and thereby send signals how to operate the system.[411] As this section argues, sending signals on how to use and operate the system in SES becomes more complex, as distribution network tariff structures cannot be based solely on energy and/or capacities, but need to take into account flexibilities and thus reflect the different capabilities and needs of system users.

"Smart" network tariff structures thus need to incorporate the flexibility capabilities of system users, but also have to cover the costs for system operation. Generally, there are mainly three categories which cause costs of system operation, namely network investments, operation and maintenance costs, and energy losses.[412] The structure of network tariffs determines the allowed revenue for system operators by prescribing for which activities and investments the operators may be remunerated and how the costs are allocated to system users. For example, allowing system operators to extensively recoup the costs for energy losses does not incentivise them to improve their system operation regarding inefficiencies and subsequent losses, as they can simply recoup the costs from the users. In this way, the regulation of distribution network tariff structures can provide for specific incentives and thereby steer system operation towards a defined overall goal.[413] There is thus a clear link between the structures of network tariffs and the incentives for more efficient, flexibility-based, (or "smart") system operation and system use. In the SES scenario, the system operators would thus need to be incentivised to harness the flexibilities of system users connected to the grid of their operational realm.

One of the main distinctive features of network tariff structures is their basis which can either depend to a larger extent on "fixed costs" (also referred to as "capacity-based costs") or on "volumetric costs" (also referred to as "usage-based costs"). Both components further unfold in various options of combinations.[414] Currently, most member states in the EU deploy a network tariff structure which is to a larger proportion based upon volumetric charges, that means, a large part of the network tariff is based on the volume of the energy distributed (kWh).[415] In turn this means that under these

411. A Picciariello, J Reneses, P Frias, and L Söder, 'Distributed Generation and Distributed Pricing: Why Do We Need New Tariff Design Methodologies?'(2015) 119 Electric Power System Research 370-376, 371.
412. María Pía Rodrígues Ortega, Ignacio Pérez-Arriaga, Juan Rivier Abbad, and Jesús Peco González, 'Distribution Network Tariffs: A Closed Question?' (2008) 36 Energy Policy 1712-1725, 1717.
413. Michiel Nijhuis, Madeleine Gibescu, and Sjef Cobben, 'Analysis of Reflectivity & Predictability of Electricity Network Tariff Structures for Household Consumers' (2017) 109 Energy Policy 631-641, 631.
414. Michael Schreiber, Martin Wainstein, Patrick Hochloff, and Roger Dargaville, 'Flexible Electricity Tariffs: Power and Energy Price Signals Designed for a Smarter Grid' (2015) 93 Energy 2568-2581, 2570.
415. *"In the electricity sector the energy component applied to households is on average 69% of the total network charge. This situation is common in most countries apart from three (The Netherlands, Spain and Sweden) where the energy charge weights between 21% and 0%. In the case of industrial clients the weight of the energy component is still dominant (around 60% for both small and large industrial clients) but there is more variability among countries and the corresponding weight ranges between 13% and 100%."* Commission of the EU, Study on Tariff Design for Distribution Systems, DG Energy (28 January 2015), 2.

revenue schemes, system operators have no interest in lowering the electricity flows in their grid (improving efficiencies), on the contrary, they even base their business model on the total volume of electricity transported. In the course of increasing amounts of decentral generation, prosumption, and the need to incentivise flexibility of system users and system operation, the volumetric-based tariff appears as insufficient and even an obstacle as it only takes into account the consumed energy. However, enabling SES, and essentially improving efficiency gains, it is not the commodity energy which is of greatest value, but the capacity and services of the grid.[416] Also the fixed-costs-based network tariff structures are problematic, as they do not incentivise system users to adjust their consumption of energy and usage to the grid according to efficiency gains, flexibility is not rewarded.[417]

Expectedly, overall consumption and grid usage become more intricate as they do not only involve the supply of electricity according to highly predictable patterns, but depend on the variability of various small-scale decentralised generation and deployed flexibility technologies. Inevitably, distributing the costs for grid usage becomes also more complex. One innovative approach suggests charging system users for specific services they require based on their deployed technologies (generation and/or flexibilities).[418] This approach is furthered by adding a peak-pricing element and fixed charges in order to improve cost-recovery for system operation.[419] The legal framework needs to incorporate the shift away from energy as the valuable and cost-determining component in distribution network pricing towards tailored services for system users with varying available capacities and thus requirements.[420] Certainly, this would increase the complexity of network tariff structures tremendously, but only if costs for system use and operation are accurately reflected, is flexibility, and thus efficiency, incentivised. This, however, requires that system users can accurately meter their grid usage and flexibility profile and also the overall electricity system state in general. The following section therefore addresses the issue of accessibility for system users to SES infrastructures as a precondition for improving efficiency gains in system operations.

416. Laura Faerber, Nazmiye Balta-Ozkan, and Peter Connor, 'Innovative Network Pricing to Support the Transition to a Smart Grid in a Low-Carbon Economy' (2018) 116 Energy Policy 210-219, 215.
417. Christos Kolokathis, Michael Hogan, and Andreas Jahn, 'Cleaner, Smarter, Cheaper: Network Tariff Design for a Smart Future' (2018) Regulatory Assistance Project, 4.
418. Toby Brown, Ahmad Faruqui, and Léa Grausz, 'Efficient Tariff Structures for Distribution Network Services' (2015) 48 Economic Analysis and Policy 139-149, 148.
419. Laura Faerber, Nazmiye Balta-Ozkan, and Peter Connor, 'Innovative Network Pricing to Support the Transition to a Smart Grid in a Low-Carbon Economy' (2018) 116 Energy Policy 210-219, 217.
420. Fiona Orton, Tim Nelson, Michael Pierce, and Tony Chappel, 'Access Rights and Consumer Protections in a Distributed Energy System' in Fereidoon Sioshansi (ed) *Innovation and Disruption at the Grid's Edge* (Elsevier Academic Press 2017) 261-287, 276.

2.2.1.2 Access to Smart Electricity System Infrastructures[421]

Ensuring that all system users have access to data through smart-metering systems is a precondition for system users to act as flexibility providers (as outlined above in section 2.2.1). Furthermore, to establish a competitive market environment for flexibilities it is necessary to ensure that the access to SES infrastructure is based on the general principle of non-discrimination. This section argues that with the changing notion of the electricity system by enhancing it with communication networks, access to SES would need to include non-discriminatory access to a minimum set of ICT infrastructures which are indispensable for system users to participate in SES. Network industries, such as the electricity sector and the telecommunications sector, require rules which organise the access to the infrastructure. With the overall aim to facilitate a liberalised and competitive sector, these rules are indispensable for establishing a level-playing field and legal certainty for users seeking access to the infrastructure.[422] This allows for equal conditions to participate in the market and thus ideally leads to market competition.[423]

Whereas the electricity system consists of only one grid to which access has to be provided, the variety of technologies in communication systems allows for the existence of parallel systems (different technology based networks) to which access can be provided. This difference is also reflected in the existing regulatory access regimes. The legal framework of the EU electricity sector requires member states to oblige DSOs to connect customers to the grid, and thereby provide access to the system. The rules on access to communication systems is quite different. Here the idea is that consumers only have to receive minimum guarantees, as the potential competition (among parallel systems, different technologies) would be higher in the telecommunication sector (the access regimes are outlined in greater detail below in section 3.2). Consequently, the variety of communication systems that would be deployed for SES purposes leads to several options that could offer users access to SES communication services. This is in line with chapter 3, which explained that communication networks for SES can include various technologies for the different purposes and quality requirements for SES communications.[424]

421. This section is to a large extent based on the following article: Lea Diestelmeier and Dirk Kuiken, 'Smart Electricity Systems: Access Conditions for Household Customers Under EU Law' (2017) 1(1) European Competition and Regulatory Law Review 36-46.
422. Hannah Kruimer, 'Non-Discriminatory Energy System Operation: Lessons learned from Telecommunications and Public Procurement' (2011) Fourth Annual Conference on Competition and Regulation in Network Industries, 8.
423. Lea Diestelmeier and Dirk Kuiken, 'Smart Electricity Systems: Access Conditions for Household Customers Under EU Law' (2017) 1(1) European Competition and Regulatory Law Review 36-46, 40.
424. See chapter 3, section 2.2.3 "Communication Networks and Smart Meters".

4

A legal framework for SES needs to ensure that system users have sufficient access to SES infrastructures on the basis of non-discriminatory conditions. The current electricity system is defined by the purpose of its operation, which is the *"transport of electricity* […] *with a view to its delivery to customers"*.[425] SES require an enhanced definition, including the purpose of electricity transmission with a view to the delivery and realising efficiency gains on basis of real-time information on production, consumption and grid capacity. For realising the efficiency gains in the SES, it is crucial that system users can access the necessary information at specified time intervals. To this end, system users need access to communication services of sufficient quality standards, which are able to provide them with the necessary information at a reasonable price. Providing system users with access to SES communication networks and data exchanges also enables system users to start interacting in new ways as market participants. The next section elaborates on this by outlining how the availability and transparency of data renders interactions of system users in SES.

2.3 Interactions on the Basis of Data Autonomy

SES run on data (also referred to as "information") on the availability and respective prices of electricity, flexibilities, and grid capacities. The transparency and access to data enables interactions, essentially transactions, among system users *inter se* and between system users and system operators. Core to the idea of SES is an increased level of interaction among system users and system operators in order to harness flexibilities in the most optimal way.[426] Ideally, SES enable every system user to access data on price signals which also allows them to autonomously engage in transactions independently from third parties (suppliers). Next to aggregation models, this requires the legal framework for SES to allow ways of peer-to-peer transactions, meaning that system users may enter into direct transactions with each other.[427] At the same time, however, the legal framework would need to establish novel forms of responsibility for supply and protection mechanisms for transactions between peers. This could be referred to as a safety-net for the case of non-compatibility between peers or inability of system users to engage in flexibility provisions putting them at a disadvantageous position.

Currently, transactions in the electricity sector are facilitated through third parties, suppliers, who connect producers and consumers by compiling and coordinating information on loads and generation and contracting subsequent supply services and

425. Art. 2(3), 2(5) Directive EC 2009/72 and C- 439-06 *Citiworks* [2008] ECR I – 3913, para 51.
426. Lea Diestelmeier and Dirk Kuiken, 'Smart Electricity Systems: Access Conditions for Household Customers Under EU Law' (2017) 1(1) European Competition and Regulatory Law Review 36-46, 36.
427. James Johnston, 'Peer-to-Peer Energy Matching: Transparency, Choice, and Local Grid Pricing' in Fereidoon Sioshansi (ed) *Innovation and Disruption at the Grid's Edge* (Elsevier Academic Press 2017) 319-330, 322.

responsibilities. This way of organisation has been successful, firstly, as it corresponds to the technical setting of the electricity sector (which was earlier described as "top-down" setting), and secondly, because centrally contracting supply services lowers transaction costs between trading parties. Related to that and speaking in more abstract terms, third parties, suppliers, also function as trust-substituting middlemen, they mitigate the lacking knowledge about the transacting partner. Trust is at the core off all transactions and essentially depends on reliable and transparent access to information.

While currently access to this information is reserved to intermediating entities (suppliers), SES enable the accessibility and exchange of information between all system users (and even devices). The preceding section argued that this extends the notion of the electricity system beyond the electricity cables and the metering points of system users to everything connected to the system. Not only does this allow system users to keep a constant overview of the costs for flexible energy and system use (as outlined above in section 2.1), but also does it empower system users or even devices to become direct trading (transacting) actors as they possess over their own generated data, but also over data regarding the system as a whole. This is usually referred to as peer-to-peer (P2P) transactions. While P2P transactions could even further sophisticate the optimisation of flexibility by matching a greater variety of sources, the supply of electricity still needs to be ensured and should not depend on complete random capabilities and compatibilities of system users being able or willing to enter into transactions (or not). The availability and accessibility of data is thus not only a measure to determine exact pricing of energy-, grid-, and flexibility capacities, but, and as explained in the following subsections, it also changes the way interactions are undertaken in SES in comparison to the incumbent organisation of interactions. This requires the legal framework to enable new forms of interactions, but also to adjust and develop a protection regime regarding compatibility and reliability of electricity supply among peers and/or system operators.

2.3.1 In between Self-Responsibility and Protection[428]

A legal framework enabling interactions on the basis of data autonomy thus needs to allow system users to engage autonomously in direct transactions, but also it needs to provide a safety-net ensuring reliable electricity supply and distribution for the case incompatibility or incapability of system users. This requires the legal framework

428. This section (including the subsections) is to a large extent based on the idea incorporated in the following article (only available in Dutch): Lea Diestelmeier and Marlies Hesselman, 'De positie van huishoudelijke consumenten in het EU Winterpakket: Tussen participeren en beschermen' (2018) 1-2(special issue Winterpakket) Nederlands Tijdschrift voor Energierecht 31-40. (only available in Dutch).

to balance between an increased level of self-responsibility of system users and yet fulfilling the need for protective measures ensuring the supply and distribution of electricity. The following two sections discuss both issues.

2.3.1.1 Peer-to-Peer Transactions[429]

Generally, third parties facilitating transactions have a trust-substituting function as they ensure credibility of strangers entering into transactions. Recently, trust in transactions can also be built by the online world and subsequent digital platforms connecting strangers and at the same time mitigating risks.[430] Envisaged P2P transactions enabled by SES are sometimes compared to developments in other sectors which have been transforming by means of the availability and transparency of information for peers, such as the car-sharing business by "Uber" and the vacation housing sector by "AirBnb".[431] The underlying idea of those businesses is to exploit unused capacities of cars and housing by connecting peers possessing and/or demanding those resources. In this context reference is often made to what is called "sharing economy". In its most basic form "sharing economy" can be understood as follows: *"consumers granting each other temporary access to under-utilised physical assets ("idle capacity"), possibly for money."*[432] The three key elements are thus "user-to-user transactions", "temporary access to a good", and thirdly, "remuneration". All three elements apply to the electricity sector, more specifically, to SES, in which system users (or devices) start interacting with each other.

The availability and accessibility of data enabled by SES can form a similar trust substitute as a precondition for transactions between system users (peers) *inter se*, but also among system users and system operators or aggregators. As outlined in the preceding sections, currently, consumers are mainly contracting electricity supply services for flat-rate, location independent tariffs. Electricity which is generated behind the meter on the consumers' premises and which is not self-consumed and fed into the grid is remunerated according to national support schemes or compensation mechanisms which are commonly designed as follows:

429. This section is to a large extent based on the idea incorporated in the following article: Lea Diestelmeier, 'Changing Power: Shifting the Role of Electricity Consumers with Blockchain Technology – Policy Implications for EU Electricity Law' (2019) 128(special issue "Energy Law and Policy") Energy Policy 189-196.
430. Koen Frenken and Juliet Schor, 'Putting the Sharing Economy in Perspective' (2017) (23)6 Environmental Innovation and Societal Transition 3-10, 4.
431. Christos Kolokathis and Michael Hogan, 'New Research: Europe's Electricity Networks are Underused and can cope with Electric Cars' (13 April 2018) Energy Post and Keith Bell and Simon Gill, 'Delivering a Highly Distributed Electricity System: Technical, Regulatory and Policy Challenges' (2018) 113 Energy Policy 765-777, 772.
432. Koen Frenken, Toon Meelen, Martijn Arets, and Pieter van de Glind, 'Smarter Regulation for the Sharing Economy' The Guardian (20 May 2015).

> *"There are three different systems in EU Member States: some systems enable prosumers to feed the electricity to the grid but only if it is done for free, others offer prosumers regular compensation for their surplus electricity through a reduction in their energy bills, whilst some systems establish a financial retribution at a price of the electricity sold."*[433]

As discussed in the preceding sections, this form of remuneration does not entail any incentive to adjust demand according to the availability of variable RES and grid capacities. The contrary is the case, as the incumbent legal framework incentivises the generation on basis of RES which fosters the stress on grid capacities and thus exacerbates energy inefficiencies. Utilising variable RES requires thus rewarding demand-side flexibility technologies and incentive schemes which render the currently passive electricity consumers in active market participants.[434] While this relates to the form of remuneration and thus also pricing schemes as discussed in the previous sections, this also raises the question with whom the system users (here mentioned as prosumers) can actually enter into transactions. Possibly, with the availability and transparency of information on real-time prices, system users could start engaging in direct market-based transactions (P2P transactions).[435]

An example of an initial development and deployment of P2P transactions in the electricity sector that is already taking place is the Dutch company "Vandebron" (translated as *"from the source"*) which enables direct transactions between electricity producers and consumers. "Vandebron" offers an online market platform for producers of decentralised RES and consumers who consciously choose to support local RES generation. Both, producer and consumer pay a flat subscription fee and can then directly enter in transactions. Here, "Vandebron" is still the trust facilitating entity by connecting the consumers and producers and the official supply company. However, trust does not necessarily need to be facilitated by a third party, but, as outlined above, can for example also be established by technology and accessible and transparent data. While the company "Vandebron" is a pioneer in the current electricity sector by shifting the business model of traditional suppliers based on the commodity energy towards

433. See for an overview of remuneration and compensation schemes of residential prosumers in EU member states European Commission, 'Study on "Residential Prosumers in the European Energy Union" (2 May 2017), JUST/2015/CONS/FW/C006/0127 Framework Contract EAHC/2013/CP/04, p. 38.
434. Saskia Lavrijssen, 'Power to the Energy Consumers' (2017) European Energy and Environmental Law Review, 172-187, 172.
435. Sandra Bellekom, Maarten Arentsen, and Kirsten van Gorkum, 'Prosumption and the Distribution and Supply of Electricity' (2016) 6(22) Energy, Sustainability and Society 1-17, 2 and James Johnston, 'Peer-to-Peer Energy Matching: Transparency, Choice, and Local Grid Pricing' in Fereidoon Sioshansi (ed) *Innovation and Disruption at the Grid's Edge* (Elsevier Academic Press 2017) 319-330, 322.

offering a digital platform for transactions, in SES, novel increased levels of interactions and novel forms of transactions are even necessary for further optimising harnessing flexibilities of all system users and devices.

To enable system users to develop into transacting peers, the legal framework needs to allow for decentralised forms of electricity supply and flexibility provision. The example of the company "Vandebron" illustrates that digital platforms can facilitate P2P transactions. The question however is how to establish safeguards for electricity supply in case of non-compatibility between transacting parties or possibly also inability of system users to engage as flexibility providers. The following section complements the idea of P2P transactions by outlining the need for a legal framework establishing a "safety-net" for electricity supply in a setting with decentralised interactions.

2.3.1.2 Safety-Net for System Users

The preceding sections overall suggest a shift from conventional consumers towards system users which are defined on the basis of their flexibility profiles and who are incentivised to invest in- and use flexibility technologies. The possibility of P2P transactions would even further the changing role of consumers by fully empowering them as self-responsible market actors, determined by their commercial flexibility profile.[436] However, system users also remain dependent on reliable and affordable electricity supply and system operation. Under the current legal framework, consumers are subject to a protection regime, as they are considered to be the weaker participants in the market. This setting may become obsolete in a SES setting which enables consumers to become market-based flexibility providers and even transacting peers. While this presupposes a large extent of self-responsibility of system users, the need for a protective element remains in order to ensure the reliable and affordable supply of electricity. The question is who would need to fall under the protection regime and under which conditions, and how protection is designed in SES.

Currently, household customers and small enterprises enjoy a high level of protection. Those system users are considered to form the same class and Directive 2009/72 provides explicit protection measure for household customers and small enterprises by requiring member states to ensure universal service for them which is defined as *"the right to be supplied with electricity of a specified quality within their territory at reasonable, easily and clearly comparable, transparent and non-discriminatory prices."*[437] However, in SES the assumption of the homogenous group of customer class defined

436. Keith Bell and Simon Gill, 'Delivering a Highly Distributed Electricity System: Technical, Regulatory and Policy Challenges' (2018) 113 Energy Policy 765-777, 772.
437. Art. 3(3) Directive 2009/72/EC.

as "households and small enterprises" is not valid anymore, as system users vary according to their flexibility profiles and not by an overall generalised definition based on presupposed consumption patterns. Expectedly, the technical functionalities of SES render consumers into a much more heterogeneous group depending on the quality of their flexibility profile.[438] Clearly, a consumer who possesses, for example, a home battery, an electric vehicle, SHTs, and solar panels can react with a much higher quality of flexibility (larger capacity and various timeframes) than a consumer who does not possess over these technologies. Consequently, consumers, or system users, can vary to a large extent in their abilities to act and react as market participants as it is the degree of "smartness" (that is the ability to respond with flexibility technologies) which renders system users in different categories. This also changes their needed level of protection and required services.

While the current protection regime assumes comparability between all household customer and small enterprises, the heterogeneity of system users in SES requires the legal framework establishing a protection regime which is much more precisely tailored to specific needs of system users than the incumbent overarching universal protection regime. Some groups of system users might be disadvantaged in venturing investments in flexibility technologies and are subsequently unable to engage as flexibility providers and cannot harvest the benefits of dynamic pricing schemes.[439] Also system users with flexibility technologies might not always be able to bring in their full extent of flexibility and choose to rely on continuous supply. For those circumstances, the legal framework needs to provide safety-net options for system users. While the legal framework can retain the universal character of protection, it needs to incorporate supplementary options for system users to select additional protection elements. In this way the legal framework would still need to incorporate minimum universal standards plus a choice model for system users with a low-quality flexibility profile which is insufficient for benefitting from dynamic pricing or aggregation models. In this way, the legal framework could facilitate combining self-responsibility of system users and protection by offering a greater choice of options between investing in- and using flexibility technologies and enjoying minimum and possibly supplementing protective measures.

4

2.4 Synthesis: A Reflective Legal Framework for Reflective Systems

This section identified the main topics for a legal framework for SES on basis of the core technical functionalities of SES, namely flexibility technologies, communication networks, and data, and their impact on the changing role of system users, the system,

438. Chapter 3 outlined the qualities of flexibilities. See chapter 3, section 2.1.1 "Flexibility Technologies".
439. Grayson Heffner, 'Smart Grid – Smart Customer Policy Needs' (2011) International Energy Agency 517-524, 520.

and interactions. The main difference between the conventional electricity system and SES is that the technical functionalities of SES render the electricity system in a "reflective system". "Reflective system" means that the system is capable of taking into account all connected system users and devices for the purpose of efficient system operation. Understanding SES as "reflective systems" further discloses the rationale behind SES as efficiency-enhancing systems which is incorporated by economic signals and incentives. This in turn, and as this section explained and analysed, changes the role of system users, the system, and interactions in the electricity sector which needs to be facilitated by a legal framework for SES. The three segments however are highly interdependent and cannot be understood or implemented in isolation. Therefore, this research emphasises that a legal framework for SES needs to be developed holistically on the basis of the technical functionalities and their impacts on the segments of the electricity sector, -users, system, and interactions. Along those segments and summarising the main findings, the following three main topics for a legal framework for SES were identified:

1. *System users as flexibility sources*
   Flexibility is inherent in SES. While chapter 3 outlined flexibility as the core technical functionality of SES, this section outlined how flexibility changes the role of system users. To enable their role as flexibility providers, this section argued that the legal framework needs to establish dynamic pricing, in its most exact form RTP, as default pricing mechanisms and allow for aggregators as commercial agents for system users.

2. *Electricity Systems and ICTs*
   Flexibilities of system users can only become valuable if the core maxim of system operation is determined as efficiency gains by optimal system usage. The legal framework therefore needs to incorporate distribution network tariff structures which reflect the complexity of cost causation of electricity supply and distribution and establishes non-discriminatory access conditions for all system users to SES infrastructures.

3. *Interactions on the basis of data autonomy*
   Incentivising system users to engage in flexibilities provision and ensuring non-discriminatory access to data, enables increased levels of interactions among system users *inter se* and system users and system operators. The legal framework therefore needs to allow for ways of P2P transactions in order to optimise harnessing flexibilities. Additionally, the legal framework also needs to establish a safety-net for supply services as a protection element for system users.

While this section formed the core of this chapter by sketching the main topics of a legal framework for SES on basis of their technical functionalities, the next section identifies and analyses main obstacles under the current legal framework for realising the envisaged legal framework for SES. This further leads to the question how to adjust the legal framework in order to enable and incentivise SES.

3. OBSTACLES FOR SMART ELECTRICITY SYSTEMS UNDER THE CURRENT LEGAL FRAMEWORK

The previous section identified and outlined the main topics for a legal framework for SES based on their core technical functionalities and their impact on the role of system users, the system, and interactions. The section developed those ideas regardless of the current provisions of the current legal framework. However, in order to accomplish the adjustment of the current legal framework for SES, it is relevant to identify how the above outlined SES legal framework differs from the current legal framework and if provisions impede SES. Essentially, the question is what does the above developed legal framework for SES mean for the current core rationales and provisions of the legal framework of the electricity sector? This step is relevant in order to relate findings of this research to the current legal framework and advance the actual development of a legal framework which enables and incentivises SES.

The above identified changing roles of system users, the system, and interactions among system users and system operators all impact the main rationales and provisions of the current legal framework. This section is thus structured along the main aims and subsequent provisions of the current legal framework. On basis of chapter 1, those can be identified as liberalisation (and the subsequent provisions to strictly unbundle network-related tasks and market activities for the purpose of independent grid operation), access conditions for system users, consumer protection measures and subsequent provisions to ensure affordable electricity supply continuously, and the aim to incentivise electricity on basis of RES and related provisions providing financial support to this aim. The following subsections mirror the findings from the preceding section 2 along those core topics of the current legal framework.

3.1 Independent Grid Operation

Driven by the overall aim of liberalisation, one of the core measures of the current legal framework is determining the boundaries between potential market activities and the network tasks. This division further manifests itself in the exact demarcation of tasks between actors, more specifically system operators (for transmissions and distribution levels) and market actors (producers and suppliers). The preceding sections argued that SES can be understood as "reflective" systems, which are capable of considering all connected system users and every device for the operation of the system on the basis of real-time data. Accordingly, every system user and every device contributes to system operation by offering flexibilities on market-based prices. The market realm is thus extended to actors (and devices) who have not been actively participating in the market and the exact demarcation between the market and the network is refined by the availability of precise data. This was described above as "extending the electricity system beyond cables and meters". Therefore, a legal framework for SES needs to be more nuanced on the demarcation of networks and markets and subsequent task divisions.

Currently, the DSOs possess a key role as system operators in the distribution system as Directive 2009/72 clearly designates the DSO with the task of

> *"ensuring the long-term ability of the system to meet reasonable demands for the distribution of electricity, for operating, maintaining and developing under economic conditions a secure, reliable and efficient electricity distribution system in its area with due regard for the environment and energy efficiency."*[440]

As explained in chapter 1, the DSOs are subject to unbundling requirements, which means that they cannot engage in generation and supply. However, in contrast to TSOs which are governed by ownership unbundling, the minimum requirement for DSOs is legal unbundling which does not entail the obligation to separate the ownership of assets.[441] Furthermore, two exceptional conditions allow derogating from the general unbundling regime for DSOs, either when the DSOs serve less than 100.000 customers, or when they serve what is defined as "small isolated systems".[442] The reason for those more lenient unbundling requirements results from the fact that the large majority of generation is not connected to the distribution grid, consequently, DSOs are considered not even being in the position to discriminate against system users for their own advantage as an integrated undertaking. This is changing in those electricity systems which are enhanced with communication networks and the availability of data on generation, load, and flexibilities of all system users and devices (SES). The EU Commission recognised with regard to the SES scenario that

440. Art. 32(1) Directive 2009/72/EC.
441. Art. 26(1). Directive 2009/72/EC.
442. Art 2(26) Directive 2009/72/EC: *"'small isolated system' means any system with consumption of less than 3000 GWh in the year 1996, where less than 5% of annual consumption is obtained through interconnection with other systems".*

> *"DSOs would obtain access to detailed information about consumers' consumption patterns, which could give DSOs a considerable competitive advantage over other market actors in offering tailor-made services to consumers. The regulatory setting will need to ensure that these risks are properly addressed".*[443]

This concern is in line with the argument of this section that unbundling rules need to be more nuanced and sophisticated in a legal framework for SES as the technical and the economic setting of the system changes.

It is thus the current technical setting of the system which requires that the task of distribution system operation is centrally organised. SES functionalities however allow for operating ever smaller units of the grid which do not necessarily need to be unified and managed by one designated DSO. The contrary is the case: Ideally, every system user is incentivised to balance its own energy and system use by means of flexibility in generation and load technologies. At the same time however, the need for system operation and more specifically the coordination of data exchanges remains and even becomes more crucial in SES, requiring sophisticated unbundling rules. Instead of the incumbent actor-based approach, unbundling rules for SES need to consider the capabilities of system users and the goal of system operation, namely efficiency gains.

3.2 Access[444]

As it was outlined above, access rules to networks is a precondition for establishing a level-playing field for system users seeking participation in the market.[445] Current electricity sector legislation therefore prescribes the obligation for system users to provide access at non-discriminatory conditions.[446] Section 2.2 described that SES are electricity systems which are enhanced by communication infrastructures. This requires extending the access conditions for system users to minimum standards for access to communication networks which are dedicated and suitable for SES purposes. Only then can system users be enabled to function as envisaged flexibility providers in SES.

EU legislation progressively fostered a system of non-discriminatory third-party access (TPA) to the electricity system.[447] This is facilitated by the freedom of choice for all

443. European Commission (2011), Communication from the Commission. Smart Grids: From Innovation to Deployment. Brussels, 12.4.2011, p.10.
444. This section is to a large extent based on the following article: Lea Diestelmeier and Dirk Kuiken, 'Smart Electricity Systems: Access Conditions for Household Customers Under EU Law' (2017) 1(1) European Competition and Regulatory Law Review 36-46.
445. See above section 2.2.1.2 "Non-Discriminatory Access to Smart Grid Infrastructures for System Users".
446. Art. 12(f) for TSOs and art. 25(2) for DSOs Directive 2009/72/EC.
447. See chapter 1, section 3.1.3 "System Operation".

customers to choose their supplier and by the freedom of suppliers to deliver to their customers.[448] To this end, "access to the system" is *"rather* […] *a right to demand a particular service from the energy system operator"*.[449] Furthermore, ECJ stated that *"the term 'access' is linked to the supply of electricity, including amongst other the quality, regularity and cost of the service."*[450] Contrary to the electricity sector, in the telecommunication sector a system operator is not offering the services related to access, it only provides a network.[451] It is the service provider that offers the end-user services, such as Internet or telephony.[452] EU legislation generally distinguishes between two different types of electronic communication services to which different access regimes apply. The first type is electronic communication services to which general EU telecom consumer protection apply. Examples of such provisions are minimum contract terms, transparency, quality of service (information) requirements (to be determined by NRAs), provisions on the duration terms of contracts, and switching provisions.[453] The second type of services are universal services, for which the provider of such a service has to ensure affordable services at a specified quality levels for all users, regardless of their geographical position.[454] One example of such a service is the provision of a communication service that allows for data communication *"*[…] *at data rates that are sufficient to permit functional Internet access* […]*."*[455] The requirement to provide "functional internet access" is vague and does not entail a quality standard for data rates which are needed for SES. This poses the risk that system users suffer considerable disadvantages by not being able to access data for SES purposes at comparable rates.

In comparison, under EU legislation, access conditions to electricity systems are thus more absolute than those applicable to communication systems. The main reason for this is the greater variety of technologies available for the transmission of electronic communication services. While the electricity system technology is, and even needs to

448. Recital 3-4 Directive 2009/72/EC and C-439-06 *Citiworks AG* [2008] ECR I – 3913, para 43.
449. C-239-07 *Julius Sabatauskas and Others* [2008] ECR I – 7523, para 42 and Alexander Kotlowski, 'Access Rights to European Energy Networks – A Construction Site Revisited' in Bram Delvaux, Michaël Hunt and Kim Talus (eds), *(eds) EU Energy Law and Policy Issues – ELRF Collection,* (2nd edn Intersentia 2009), 8.
450. C-239-07 *Julius Sabatauskas and Others* [2008] ECR I – 7523, para 40.
451. Art. 2 (c) Directive 2002/19/EC on Access to, and Interconnection of, Electronic Communications Networks and Associated Facilities [2002] OJ L 108/7. In the following Directive 2002/19/EC and Access Directive. And art. 2(a) and (c) Directive 2002/21/EC on a Common Regulatory Framework for Electronic Communications Networks and Services [2002] OJ L 108/33. In the following Directive 2002/21/EC and Framework Directive.
452. It is however possible that the service provider is also the operator of the network.
453. Art. 20–22 and art. 30 Directive 2002/22/EC on Universal Service and Users' Rights relating to Electronic Communications Networks and Services [2002] OJ L 108/51. In the following Directive 2002/22/EC and Universal Service Directive. See further Ian Walden (ed), *Telecommunications Law and Regulation* (4th edn, Oxford University Press 2012), 456–462.
454. Art. 2(j) and 3(1) Framework Directive, art. 3 Universal Service Directive, and Paul Nihoul and Peter Rodford, *EU Electronic Communications Law: Competition and Regulation in the European Telecommunications Market* (2nd edn, Oxford University Press 2011), 306–307.
455. Art. 4(2) Universal Service Directive.

be, uniform for operation, telecommunication technologies can vary. This also requires EU regulation to be broader in order to capture the variety of technology applied throughout the member states. This broad character is likely to become an obstacle, as communication systems are inherent to SES. A legal framework which enables SES therefore needs to establish an integrated access regime for system users engaging in SES which encompasses electricity systems including the necessary ICT infrastructure for participation in SES. This would also include specific quality requirements for communication infrastructure for SES. Currently, EU legislation on access to electricity systems and to communication system does not provide a guarantee for system users to access SES, which would essentially hinder their participation as "flexibility providers" and limit their ability to gain from dynamic prices.[456]

3.3 Consumer Protection

As chapter 1 explained, liberalisation is not a goal in itself but strives for increasing overall welfare in the sector. While consumer welfare is at the core which is ideally reflected in lower prices, thus financial gains for consumers, and the choice for consumers between different suppliers, liberalisation also evoked the quest for consumer protection instruments in the sector. This is especially relevant for small customers (households and small enterprises) who are connected to the distribution grid. The current legal framework is thus geared towards affordable and continuous supply at affordable costs. On the contrary, the core of the idea of SES is to enable most exact pricing for energy and grid usage and to assign the costs to the person who induced them. While in the current electricity sector, system users are not incentivised to adjust their behaviour according to energy- or grid restraints, the main technical functionalities of SES provide those incentives and technical conditions and thereby render consumers into system users, or as mentioned above, even into system shapers. Accordingly, the protection regime for electricity consumers, or better, system users or shapers, in SES, needs to provide for more tailor-made protection options which do not constrain or even nullify the incentive of investments in- and use of flexibility technologies.

The current protection regime for consumers is to a large extent based on cross-subsidisation between consumers, as prices are not reflecting the individual costs of system users.[457] The different usage of energy and grid capacities remains obscure to most consumers, due to lacking information a flat-rate charge for all consumers is perceived as "fair".

456. Lea Diestelmeier and Dirk Kuiken, 'Smart Electricity Systems: Access Conditions for Household Customers Under EU Law' (2017) 1(1) European Competition and Regulatory Law Review 36-46, 46.
457. See preceding sections on dynamic pricing and network tariff structures.

> *"A flat rate that charges the same price around the clock essentially creates a cross-subsidy between consumers that have flatter-than-average load profiles and those that have peakier-than-average load profiles. This cross-subsidy is invisible to most consumers* […]*".*[458]

While this might be suitable for a sector with little or no flexibility of system users (consumers), this distorts the core approach of SES. As it was argued above, the underlying assumed comparability of consumers which applies in the current sector becomes void in SES, where system users can be characterised and defined on basis of the quality of their flexibility profiles. Even further, the universal protection regime might nullify the effect of dynamic pricing which essentially aims at assigning peak-prices and rewards. The above outlined idea[459] of enabling a more refined protection regime which provides universal minimum standards and supplementing protection options would take into account the needs of system users according to their available technology and willingness to balance between rewards and risk in a dynamic pricing scheme. Such a more nuanced safety-net (as it was named above) is not feasible under the current protection regime which is based on the assumption that all consumers of a specific class are comparable and therefore enjoy the same extent of protection. The current approach of the consumer protection regime therefore constitutes an obstacle for incentivising and enabling SES under the current legal framework.

3.4 RES Promotion

One of the EU policy goals is to foster the development of RES to mitigate climate change by reducing emissions from the energy sector and to improve fuel-independency from third states.[460] To achieve this end, one the main measures in the EU legal framework of the energy sector is allowing for financial support for electricity generation on basis of RES. The Renewable Energy Directive 2009/28 (RED) broadly defined support schemes as basically any financial instrument promoting the use of RES.[461] In addition, the RED required priority access for RES to the system.[462] Both measures primarily aim at incentivising the generation of RES by providing certainty to investors and producers

458. Ahmad Faruqui, 'The Ethics of Dynamic Pricing' (2010) 23(6) The Electricity Journal 13-27, 19.
459. See section 2.3.1.2 "Safety-Net for System Users".
460. See chapter 1, section 3.2 "Climate Change Mitigation".
461. Art. 2(k) Directive 2009/28/EC: "[…] *any instrument, scheme or mechanism applied by a Member State or a group of Member States, that promotes the use of energy from renewable sources by reducing the cost of that energy, increasing the price at which it can be sold, or increasing, by means of a renewable energy obligation or otherwise, the volume of such energy purchased. This includes, but is not restricted to, investment aid, tax exemptions or reductions, tax refunds, renewable energy obligation support schemes including those using green certificates, and direct price support schemes including feed-in tariffs and premium payments."*
462. Art. 16(2b) Directive 2009/28/EC: *"Member States shall also provide for either priority access or guaranteed access to the grid-system of electricity produced from renewable energy sources"*

for recouping investments in RES generation.[463] These measures are motivated by the aim to enable member states to reach the binding targets of RES as established by the RED.[464] This approach however does not consider system constraints and stress caused by the increasing amounts of variable RES. As explained in chapter 2, the rationale of SES is emphasising efficiency gains in the system. Therefore, a legal framework which allows for financial support schemes which do not take into account the need for the efficient usage of RES and on top of that imposes the obligation of unconditional priority access to the grid infrastructure is not compatible with SES. Instead, the approach of a legal framework for SES which furthers the overarching aim of the development of a low-carbon society by means of RES needs to focus on efficiency and market-based approaches for integrating RES.

Instead of promoting the mere generation and consumption of RES, a legal framework for SES needs to incentivise primarily flexibilities of system users. Increasing amounts of RES will not lead to the desired low-carbon society, if RES are not efficiently harnessed. The contrary is the case, increasing amount of variable sources even foster the need for balancing capacities on the basis of conventional sources, leading to generation capacities which are to a large extent left idle and which require capacity mechanisms. As it will be discussed further below in the context of the current legislative proposal of the EU Commission, entitled *"Clean Energy for All Europeans"* (CEP), the costs for extra balancing capacities would be passed on to consumers who would thus carry the financial burden of increasing amounts of variable RES. Instead, as outlined in chapter 2, the idea of SES is to enable the cost-efficient integration of variable RES by establishing real-time market-based price signals for system users to produce or consume and use the grid. This would assign the costs to the system user who induced the costs. Ideally, in this way, system users are incentivised to invest in- and use flexibility technologies and mitigate costs of fluctuating RES. A legal framework which enables and incentivises SES therefore needs to refrain from support schemes which promote the mere generation of RES, but needs to incentivise in a more nuanced way the efficient, flexible, use of RES and grid capacities. This would require taking into account the generation, load, and grid capacities on a smaller local scale. For example, an area (neighbourhood or district) where a large capacity of RES-based generation is already installed, even more variable RES generation would only cause unwanted stress on the system and exacerbate inefficiencies. In this case, support schemes would thus need to incentivise flexibility technologies, such as SHTs, electric cars or batteries. On the one hand, support

463. The measure of priority access to the system is repealed in the revised RES Directive 2018/2001/EU.
464. Art. 3(1) Directive 2009/28/EC, the targets for the individual member states are established in table A of Annex I of that Directive.

schemes would thus need to be designed more broadly to capture a greater variety of technologies, and not only RES generation technology, on the other hand, support schemes would need to be more specific in their implementation regarding the location. Inevitably, this would require much more sophisticated ways of coordination than the current support scheme system as may more factors would need to be considered. This is in line with the main finding of chapter 3 which argued that a legal framework for SES needs to be technology-neutral and goal-oriented. The design of support schemes for SES is one example for this claim, as it would not only support RES generation, but more generally, support efficiency gains in electricity system operation.

On the basis of section 2 which outlined the main topics for a legal framework for SES, this section distilled the main obstacles under the current legal framework for SES. As mentioned in the introduction, the legal framework of the electricity sector is tailored to the technical and the economic component of the sector. This section further revealed how both components change in relation to SES subsequently requiring changes in the legal framework. Recently, efforts have been initiated to reform the EU legal framework of the electricity sector. The next section analyses what those changes entail and on basis of findings of this thesis and assesses whether and to what extent these could be considered as a next step towards a legal framework for SES.

4. *CLEAN ENERGY FOR ALL EUROPEANS:* A STEP TOWARDS A LEGAL FRAMEWORK FOR SMART ELECTRICITY SYSTEMS?

In the context of chapter 1, which analysed the role of law in the development of the electricity sector, the legislative proposal of the EU Commission was introduced as a response to "the electricity sector in flux", characterised by decentral generation, prosumption, and changing demand patterns.[465] As mentioned in chapter 1, the entire proposal encompasses various legal reforms for the organisation of the energy sector (and in particular the electricity sector) and overarching governance models.[466] The section specifically outlined the revised Directive on the promotion of RES which was adopted in the end of 2018 as Directive 2018/2001. This section analyses the proposal, more specifically, Directive 2018/2001 and the recast market directive 2019/--, from a different angle, namely against the background of the findings of this thesis, especially of section 2 of this chapter. The guiding question in this section is, whether, and to what extent the legislative proposal enables SES. Thereby, this chapter mirrors the findings of this thesis and bridges the findings to (ongoing) legislative development. The following

465. Chapter 1, section 4.3 "Legal Response to 'the Electricity Sector in Flux': Clean Energy for All Europeans"
466. See for specifications of the legislation to be reformed footnote 202.

two legislative proposals are considered most relevant for the this thesis: the recast directive for common rules for the internal market for electricity 2019/--,[467] and the recently adopted directive on the promotion of RES. Both (recast) directives are briefly introduced in the following two sections and then analysed in greater detail against the findings of this thesis in section 4.3.

4.1 The Recast Market Directive 2019/--

The EU Commission aims with the recast market directive to shift the focus further towards decentral electricity generation based on RES and demand-side flexibilities. The structure of the recast market directive 2019/-- reflects this aim by turning the current ordering "upside down". Whereas the current structure of definitions and provisions was ordered according to the "top-down" supply chain (from generation to transmission, to distribution, and consumption), the recast market directive 2019/-- orders the definitions exactly the other way around, starting with "customers" and ending with "producers". The overarching goal behind this shift towards inclusion of decentral structures is further lowering emissions from the electricity sector and at the same time avoiding costs of reinforcing grid infrastructures and back-up generation capacities by integrating demand-side flexibilities in the market. To achieve this goal, the EU Commission sees the integration of consumers in the electricity sector as key to the attainment of the "energy transition". Under the heading *"putting consumers at the heart of the energy market"*, the EU Commission states in its proposal for the legislative reform that

4

> *"Fully integrating industrial, commercial and residential consumers into the energy system can avoid significant costs for 'backup' generation; costs which consumers would otherwise end up paying. It even allows consumers to benefit from price fluctuations and to earn money through participation in the market. Activating consumer participation is therefore a prerequisite for managing the energy transition successfully and in a cost-effective way."*[468]

This approach is closely connected to the idea of SES as conventional consumers are considered in the electricity supply chain as flexibility providers for the system.

467. The recast market directive is close to adoption, however, the final number of the reformed directive is not yet known. Therefore, this thesis still applies the term "recast market directive 2019/--", even though it is not expected that fundamental changes to the text are introduced in the legislative process at this stage. The numbering of articles is based on the version which was adopted by the European Parliament 26 March 2019 in the first reading of the ordinary legislative procedure, document A8-0044/2018. In case an earlier version of the legislative proposal is referred to, the date of that document is provided in the references.

468. Commission of the EU, 'Proposal for a Directive on Common Rules for the Internal Market in Electricity COM (2016) 864 final/2 (30.11.2016), p. 4.

Essentially, the aim is to harness efficiency, for example by *"avoiding costs for 'backup' generation"* and thereby mitigate costs of fluctuating RES. The rationale is thus to provide a level-playing field between supply side sources and demand flexibility facilitating the transition towards a low-carbon based sector. Section 4.3 further elaborates on specific provisions of the recast market directive.

4.2 Directive 2018/2001/EU on the Promotion of RES

The shift towards integrating demand-side flexibilities as envisaged by the recast market directive is also addressed by Directive 2018/2001 which fosters aims to increase the share of RES. In contrast to the previous RES directive 2009/28 which established targets for each member states in the share of RES in final consumption,[469] Directive 2018/2001 establishes a binding Union target for the overall share of energy from renewable sources in the Union's gross final consumption of energy in 2030.[470] Additionally, member states need to fulfil a baseline in gross final consumption of RES as of 2021.[471] According to the EU Commission, a Union-wide target provides greater flexibility for the member states to meet their GHG reduction targets "[…] *in the most cost-effective manner in accordance with their specific circumstances, energy mixes and capacities to produce renewable energy."*[472] Along with the increased level of flexibility, and continuing the approach of its predecessor, one of the main aims of Directive 2018/2001 is strengthening long-term certainty for investor by ensuring predictability of RES plans and by reducing administrative barriers.[473] The definition of support schemes remains largely the same, including a variety of financial measures reducing the costs of RES. The initial proposal of the EU Commission included a mandatory opening of support schemes to RES installations located in another member state.[474] The final adopted text of the directive omits this obligation by leaving the opening of support schemes at the discretion of the member states.[475] Important to mention is the removal of the privilege of RES sources having priority access to the grid as established by the current RES directive 2009/28.[476] The removal of this benefit requires furthering flexibility technologies in order to capture peaks in RES generation which cannot be

469. See chapter 1, section 3.2.2 Promoting Electricity from Renewable Energy Sources.
470. Art. 3(1) Directive 2018/2001/EU.
471. Art. 3(4) and Part A Annex I Directive 2018/2001/EU.
472. Council of the European Union, Proposal for a Directive of the European Parliament and of the Council on the Promotion of the Use of Energy from Renewable Sources. Inter-institutional File 2016/0382 (COD) (Brussels 21 June 2018), 6.
473. Art. 6 and 15(3) Directive 2018/2001/EU.
474. Art. 5 Commission of the EU, Proposal for a Directive on the Promotion of the Use of Energy from Renewable Sources, COM(2016) 767 final/2 (23 February 2017).
475. Art. 5 Directive 2018/2001/EU.
476. Art. 16(2b) Directive 2009/28/EC.

accommodated by the grid capacity. The following sections discuss both proposals in greater detail and in relation to the preceding sections of this chapter, analysing the proposal in the light of a legal framework for SES.

4.3 CEP in the Light of a Legal Framework for Smart Electricity Systems

This section aims at analysing the question to what extent the CEP, and more specifically the recast market directive 2019/-- and Directive 2018/2001, can be considered as a step towards a legal framework for SES, as outlined above in section 2. Therefore, to connect the findings of this thesis with the law reform of the EU Commission, the following subsections analyse the CEP, more specifically, the recast market directive 2019/-- and the Directive 2018/2001, and relate the main provisions to the findings of section 2 of this chapter. This section does not exhaustively discuss all the novel definitions and provisions, but provides some exemplary issues which illustrate the approach of the reformed directives of enabling a more “clean”, and necessarily more flexible (“smart”), organisation of the electricity sector. The following sections are organised along the above established categories for a legal framework for SES, namely system users, system, and interactions, and identify to what extent the legislative proposal is in line with the findings of this research regarding the topics and approaches for a legal framework for SES as established by section 2 of this chapter.

4.3.1 System Users

In line with the overall objective of the CEP to activate demand-side flexibility, the recast market directive 2019/-- and Directive 2018/2001 aim at shifting the role of consumers towards more “active market participants”. Currently, the participation of consumers in the market is limited to the possibility of switching suppliers.[477] The recast market directive 2019/-- and Directive 2018/2001, especially the former, entail several provisions which aim at sophisticating the role of consumers in the electricity market by enabling them to engage in electricity generation and flexibility services. Connecting the proposal to the findings of this thesis, the question is to what extent do the reformed provisions enable system users to become flexibility providers? This section outlines the main provisions of the recast market directive 2019/-- and Directive 2018/2001 to assess this question.

Both, the recast market directive 2019/-- and Directive 2018/2001, provide several new definitions, which aim at capturing and institutionalising the phenomenon of what

477. However, the switching rates of consumers in the electricity markets remain rather low. Research of the EU Commission reveals that on average only 14% of the customers switch their supplier. EU Commission, Second Consumer Market Study on the Functioning of the Retail Electricity Markets for Consumers in the EU, September 2016, p. 102.

has often been referred to as "prosumers"[478] in individual- and in collective forms. The recast market directive 2019/-- proposes a new category of consumers, namely "active customers". The definition reads as follows:

> *"'active customer' means a final customer, or a group of jointly acting final customers, who consumes or stores electricity generated within its premises located within confined boundaries or, where permitted by a Member State, within other premises, or who sells self-generated electricity or participates in flexibility or energy efficiency schemes, provided that those activities do not constitute its primary commercial or professional activity;".*[479]

Analogically, Directive 2018/2001 defines a new entity named "renewable self-consumer" (RSC) as a

> *"a final customer operating within its premises located within confined boundaries or, where permitted by a Member State, within other premises, who generates renewable electricity for its own consumption, and who may store or sell self-generated renewable electricity, provided that, for a non-household renewables self-consumer, those activities do not constitute its primary commercial or professional activity".*[480]

While the definition of "active customer" also emphasises the possibility to engage in demand-response and energy efficiency schemes, the definition of RSC is more confined in the activities as the focus is on "self-consumption". This indicates that even though "storage" is mentioned as possible activity of "renewable self-consumers", storage is primarily meant for storing surpluses generated behind the meter, on the premises of the final customer, and not for demand-response participation. The "renewable self-consumer" could thus possibly be understood as a subtype of "active customer" as defined by the recast market directive.

In a similar way, the recast market directive 2019/-- and Directive 2018/2001 provide analogical definitions for communities engaging in activities in the electricity sector. Directive 2018/2001 defines

478. See chapter 1 section 4.2 "Prosumption".
479. Art. 2(8) recast market directive 2019/--.
480. Art 2(14) Directive 2018/2001/EU. In addition, and analogically to the definition of the recast market directive which includes "jointly acting customers", Directive 2018/2001/EU also defines in article 2(15) *"'jointly acting renewables self-consumers' means a group of at least two jointly acting renewables self-consumers in accordance with point (14) who are located in the same building or multi-apartment block;".*

> *'renewable energy community' means a legal entity: (a) which, in accordance with the applicable national law, is based on open and voluntary participation, is autonomous, and is effectively controlled by shareholders or members that are located in the proximity of the renewable energy projects that are owned and developed by that legal entity; (b) the shareholders or members of which are natural persons, SMEs or local authorities, including municipalities; (c) the primary purpose of which is to provide environmental, economic or social community benefits for its shareholders or members or for the local areas where it operates, rather than financial profits;"*[481]

The recast market directive 2019/-- defines

> *"citizen energy community' means a legal entity that*
> a. *is based on voluntary and open participation and is effectively controlled by members or shareholders that are natural persons, local authorities, including municipalities, or small enterprises;*
> b. *has for its primary purpose to provide environmental, economic or social community benefits to its members or shareholders or to the local areas where it operates rather than to generate financial profits; and*
> c. *may engage in generation, including from renewable sources, distribution, supply, consumption, aggregation, energy storage, energy efficiency services or charging services for electric vehicles or provide other energy services to its members or shareholders;"*[482]

Again, the definition of Directive 2018/2001 directive appears narrower than the definition of "citizen energy communities" (CECs) in the recast market directive 2019/-- as its elements are confined to the structure and nature of the community and not to its exact tasks in the electricity sector. On the contrary, the recast market directive 2019/-- entitles CECs with a variety of tasks.[483] CECs are not only entitled to engage in distributed generation, but can also *"be engaged in electricity generation, distribution and supply, consumption, aggregation, storage or energy efficiency services, generation of renewable electricity, charging services for electric vehicles or provide other energy services"*.[484] Connecting thereto, the recast market directive 2019/-- defines aggregation as

481. Art. 2(16) Directive 2018/2001/EU.
482. Art. 2(11) recast market directive 2019/--.
483. Art. 2(11) recast market directive 2019/--.
484. Art. 2(11) recast market directive 2019/--.

"a function performed by a natural or legal person who combines multiple customer loads or generated electricity for sale, purchase or auction in any electricity market".[485]

The recast market directive 2019/-- thereby enables pooling of distributed generation and loads enhancing their potential to participate in *"any organised electricity market"*.

This is further strengthened by conditions for contractual relations. The recast market directive 2019/-- establishes the obligation for member states to ensure that final customers are allowed to conclude contracts with aggregators which does not require the consent of the final customers' supplier.[486] Furthermore, the recast market directive 2019/-- not only envisages the participation of "active customers" or aggregated organisational forms, but also entitles every final customer to a "dynamic electricity price contract",[487] which is defined as

> *"*[…] *electricity supply contract between a supplier and a final customer that reflects the price variation in the spot markets, including in the day-ahead and intraday markets, at intervals at least equal to the market settlement frequency;".*[488]

Essentially, this provision aims at bringing the benefit of market prices to all final customers who currently are exposed mainly to flat rate retail prices. The exposure to dynamic pricing also requires system users to be able to react accordingly via demand-response. The recast market directive 2019/-- defines demand-response as

> *"change of electricity load by final customers from their normal or current consumption patterns in response to market signals, including time-variable electricity prices or incentive payments, or in response to acceptance of the final customer's bid, alone or through aggregation, to sell demand reduction or increase at a price in organised markets* […]*"*[489]

The respective provisions on demand-response oblige member states to *"allow and foster participation of demand response through aggregation"* and to ensure that system operators when procuring ancillary services treat demand-response providers in a non-discriminatory manner, on basis of their technical capabilities.[490] To enable system users

485. Art. 2(18) recast market directive 2019/--.
486. Art. 13(2) recast market directive 2019/--.
487. Art. 11 recast market directive 2019/--.
488. Art. 2(15) recast market directive 2019/--.
489. Art 2(20) recast market directive 2019/--.
490. Art. 17 recast market directive 2019/--.

to make informed choices about electricity supply, the recast market directive requires that customers have free of charge access to at least one price-comparison tool and the right to a smart meter.[491]

Overall, the provisions applicable to customers of the recast market directive 2019/-- and Directive 2018/2001, especially the former, aim at steering towards further integration of conventional consumers in the electricity market.[492] The CEP proposal clearly aims at unlocking the potential demand-side flexibility of customers by defining measures such as dynamic electricity price contract and demand-response and even entitling customers to those measures. This provides preconditions for enabling system users as flexibility providers as envisaged in SES. Those preconditions were identified in section 2 as enabling dynamic pricing as default pricing mechanism and facilitating aggregation for the purpose of enhancing flexibilities and thus the market position of system users. The next section further assesses whether and how the role of the electricity system is envisaged to change in the proposal.

4.3.2 Electricity System

Shifting the role of consumers towards more active market participants and possibly flexibility providers also requires changing the notion and role of electricity systems. As it was outlined above in section 2.2, harnessing the envisaged demand-side flexibilities in the electricity system requires distribution network tariff structures which are more nuanced and tailored to the actual individual usage of system users. Furthermore, this requires non-discriminatory access conditions for system users to minimum standard communication networks which are dedicated to SES purposes. The question here is do the provisions of the recast market directive 2019/-- incentivise efficiency gains in electricity system operation as the core maxim? This section outlines the main provisions of the recast market directive 2019/-- which relate to this question.

The recast market directive 2019/-- specifically addresses the need for flexibility procurement in distribution grid operation and therefore specifies the tasks of DSOs in the use of flexibility as follows:

> *"Member States shall provide the necessary regulatory framework to allow and provide incentives to distribution system operators to procure flexibility services, including congestion management in their areas, in order to improve efficiencies in the operation and development of the distribution system. In particular, the*

491. Art. 14 and art. 21 recast market directive 2019/--.
492. Saskia Lavrijssen, 'Power to the Energy Consumers' (2017) European Energy and Environmental Law Review 172-187, 178.

regulatory framework shall ensure that distribution system operators are able to procure such services from providers of distributed generation, demand response or energy storage and shall promote the uptake of energy efficiency measures, where such services cost-effectively alleviate the need to upgrade or replace electricity capacity and support the efficient and secure operation of the distribution system. Distribution system operators shall procure such services in accordance with transparent, non-discriminatory and market-based procedures unless the regulatory authorities have established that the procurement of such services is not economically efficient or that such procurement would lead to severe market distortions or to higher congestion."[493]

The provision thus obliges member states to establish a regulatory framework which incentivises DSOs to improve efficiencies and aims at placing flexibility measures (DSR, storage, energy efficiency) on equal footing with capacity upgrades. However, the provision leaves much leniency of the exact implementation to the member states. Also the detailed design of distribution network tariffs remains subject to the member states; EU legislation merely sets the main guiding principles for tariff regulation. While setting distribution network tariffs at national level might better correspond to local system circumstances, EU legislation needs to further emphasise guiding principles for tariff structures, especially the one of cost-reflectiveness, in order to foster efficiency gains as a core maxim of system operation.

The recast market directive 2019/-- strives at enabling DSOs to procure flexibility services on the basis of transparent, non-discriminatory and market-based procedures.[494] A specific example of this, which is explicitly incorporated in the recast market directive 2019/--, is the aim to integrate electro-mobility into the electricity network.[495] As outlined above in section 3.1, this further relates to the challenges of delineating the role of DSOs with regard to current unbundling requirements. Again, this can be exemplified with the integration of electro-mobility in the network as follows: In facilitating the connection of recharging points for electric vehicles to the distribution grid, DSOs are required to *"cooperate on a non-discriminatory basis with any undertaking that owns, develops, operates or manages recharging points for electric vehicles, including with regard to connection to the grid."*[496] The recast market directive 2019/-- generally envisages a competitive market for the development and operation of recharging points by

493. Art. 32(1) recast market directive 2019/--.
494. Art. 32(1) recast market directive 2019/--.
495. Art. 33 recast market directive 2019/--.
496. Art. 33 (1) recast market directive 2019/--.

allowing DSOs only to engage if other parties have not expressed their interest to do so, the NRA has granted its approval, and the DSO operates the recharging points on the basis of non-discriminatory TPA.[497]

A similar approach is applied for storage activities. Principally, the recast market directive 2019/-- excludes DSOs from owning, managing, or operating storage facilities, unless *"where they* [storage facilities] *are fully integrated network components and the regulatory authority has granted its approval"*,[498] or if the following conditions apply: if no other party has expressed interest to engage in storage, or if such facilities are necessary for the DSO to fulfil its obligation for the efficient, reliable, and secure operation of the distribution system, the NRA needs to grant approval to both instances.[499] The DSO thus still has a foot in the door for engaging in flexibility measures for the purpose of grid operations. As it was discussed above in section 3.1, this is highly controversial, as independent grid operation in SES requires more nuanced unbundling rules. With these provisions which allow the DSO in exceptional circumstances to engage in flexibility measures, the recast market directive 2019/-- does not ensure independent grid operation in a SES setting as the DSO could favour its own flexibility services over services of other market parties. Instead, and in order to increase efficiency, flexibility would need to be procured at a market platform, for example via auction-based mechanisms. This would provide a

> "[…] *platform to monetize flexibility services independently from energy and that allows trading actions for flexibility in a specific location depending on the network condition or balancing needs. Such a local market-based environment provides a local decision making process with bilateral communication between the local system operators (DSOs) and the market participants (i.e., prosumers with flexibility). The intended framework aims to enable full use of the flexibility of households and improves economic and operation efficiency."*[500]

In such a setting, the DSO would be responsible for transporting the energy among the system users and would procure flexibility from the system users in order to maximise efficiency in system operation, but the DSO could not engage itself as a flexibility provider which would leave the market setting for flexibility provision undistorted.

4

497. Art. 33 (3) recast market directive 2019/--.
498. Art. 36 (2) recast market directive 2019/--.
499. Art. 36(3) recast market directive 2019/--.
500. Shahab Shariat Torbaghana, Niels Blaauwbroek, Dirk Kuiken, Madeleine Gibescu, Maryam Hajighasemi, Phuong Nguyen, Gerard Smit, Martha Roggenkamp, Johann Hurink, 'A Market-Based Framework for Demand Side Flexibility Scheduling and Dispatching' (2018) 14 Sustainable Energy, Grids and Networks 47-61, 49.

Section 2.2 of this chapter established that a legal framework for SES needs to establish efficiency gains as core maxim for system operation. The relevant provisions relating to this finding which are incorporated in the recast market directive 2019/-- mainly relate to the role of the DSOs whose role and tasks change with the integration of flexibility in the system. Primarily, this includes the procurement of flexibilities for system operation. While this thesis also emphasised the relevance of flexibilities for the development of SES, contrary to the recast market directive 2019/--, this thesis did not place the DSO in the centre of newly emerging tasks. On the contrary, this thesis argues that a legal framework which enables SES need to incentivise flexibility of system users which can then be procured for system operational purposes. This would exclude the possibility for DSOs to engage in flexibility provision. The provisions in the recast market directive 2019/-- also aim at market-based flexibility provision, however, until a functioning market for flexibility emerges, the DSOs might already take advantage of their option to engage in flexibility provisions and establish a central position in a market for flexibility services.

4.3.3 Interactions

Section 2.3 of this chapter outlined that the availability of data can render interactions of system users towards more self-determined transactions, which was further exemplified by the idea of P2P transactions enabled by SES. The section also emphasised that the need for minimum safeguarding measures remains as a protective element for system users to be ensured reliable electricity supply and distribution. This was referred to as "safety-net", which could include minimum universal standards plus supplementing safeguarding options for system users depending on their flexibility profile. The question with regard to the (recast) directives is thus, to what extent do the provisions allow for self-determined interactions of system users and how is this balanced with the protection of system users? This section outlines the main provisions which relate to this question.

A precondition for system users to engage in self-determined market transactions is availability and accessibility of data. As already mentioned briefly in section 4.3.1, system users are entitled the right to a smart meter.[501] The recast market directive 2019/--- defines "smart metering system" as

> "[…] *means an electronic system that is capable of measuring electricity fed into the grid or electricity consumed from the grid, providing more information than*

501. Art. 21 recast market directive 2019/--.

> *a conventional meter, and that is capable of transmitting and receiving data for information, monitoring and control purposes, using a form of electronic communication;"*[502]

Subsequent to article 19 which further encourages member states to continue the roll-out of smart meters, if the cost-benefit analysis is assessed as positive, the recast market directive 2019/-- outlines the functionalities of smart metering systems:

> "[…] *Member States shall deploy smart metering systems in accordance with European standards, Annex II and the following requirements:*
>
> *a. the smart metering systems shall accurately measure actual electricity consumption and shall be capable of providing to final customers information on actual time of use. Validated historical consumption data shall be made easily and securely available and visualised to final customers on request and at no additional cost. Non-validated near real-time consumption data shall also be made easily and securely available to final customers at no additional cost, through a standardised interface or through remote access, in order to support automated energy efficiency programmes, demand response and other services;*
>
> [requirements b, c, d, and e relate to security and reliability, privacy and accessibility of data]"[503]

Furthermore, under the title of data management, the recast market directive 2019/-- requires that "eligible parties" have access to the data of final customers.[504] Curiously, an earlier version of the proposal included the addition stating that member states need to specify the eligible parties, which shall however *"at least include customers, suppliers, transmission and distribution system operators, aggregators, energy service companies, and other parties which provide energy or other services to customers."*[505] This broad range of actors is removed in the most recent version, which provides more leniency to the member states in defining eligible actors. Article 24(3) requires establishes that

> "[…] *Member States shall ensure that electricity undertakings apply the interoperability requirements and procedures for access to data referred to in paragraph 2. Those requirements and procedures shall be based on existing national practices."*

502. Art. 2(23) recast market directive 2019/--.
503. Art. 20 recast market directive 2019/--.
504. Art. 23 recast market directive 2019/--.
505. Art. 23 recast market directive, 23 February 2017. Moreover article 24 requires member states to define *"a common data format and a transparent procedure for eligible parties to have access to the data listed under Article 23 (1), in order to promote competition in the retail market and avoid excessive administrative costs for the eligible parties."*

4

Regarding findings of the preceding section on the envisaged role of the DSO in the recast market directive 2019/--, here, the DSO is not at the centre of action. The recast market directive 2019/-- even specifies that in case DSOs are involved in data management, DSOs have the obligation of ensuring that *"all eligible parties have non-discriminatory access to data under clear and equal terms."*[506] Those provisions on access to data for final customers via smart metering system are a precondition for the above outlined actor category of "active customers" who are envisaged to store or sell electricity or participate in demand-response systems.[507] Only if data on energy- and grid capacities and related costs are available, can system users participate as "self-determined market participants".

Directive 2018/2001 directive also strives to enable novel forms of "self-determined market participation" by introducing the option of "peer-to-peer trading":

> *"'peer-to-peer trading' of renewable energy means the sale of renewable energy between market participants by means of a contract with pre-determined conditions governing the automated execution and settlement of the transaction, either directly between market participants or indirectly through a certified third-party market participant, such as an aggregator. The right to conduct peer-to-peer trading shall be without prejudice to the rights and obligations of the parties involved as final customers, producers, suppliers or aggregators;"*[508]

The possibility to engage in P2P trading is connected to the entitlements of "renewable-self consumers" (discussed above in section 4.3.1), which mention P2P trading as one option of selling excess electricity.

> *"Member States shall ensure that renewables self-consumers, individually or through aggregators, are entitled: (a) to generate renewable energy, including for their own consumption, store and sell their excess production of renewable electricity, including through renewables power purchase agreements, electricity suppliers and peer-to-peer trading arrangements,* […]*""*[509]

P2P trading is a novel concept in the electricity sector as currently solely suppliers and system operators facilitate the connection and transactions among system users. While the idea of P2P trading is gaining spirit with the availability and transparency

506. Art. 34 recast market directive 2019/--.
507. Art. 2(8) recast market directive 2019/--.
508. Art. 2(18) Directive 2018/2001.
509. Art. 21(2) Directive 2018/2001

of real-time data, it also raises questions regarding the organisation of decentralised responsibilities of supply and distribution, and, again, how self-determined market participation interacts with consumer protection measures.[510]

The (recast) directives aim at ensuring that final customers have the necessary non-discriminatory access to data and at enabling them to engage in self-determined market transactions. However, their role as participants in market interactions is not entirely clear. On the one hand, they are envisaged to engage in market-based transactions, on the other hand, they remain "consumers" per definition. This relates to the above identified dilemma of balancing between "empowerment and protection".[511]

The recast market directive 2019/-- provides for protective measures for consumers. The outset of the directive states in relation to prices that supply prices generally have to be market-based, suppliers are thus free to determine the price at which they supply electricity.[512] Yet, the same provision requires member states to "[…] *ensure the protection of energy poor and vulnerable household customers pursuant to Articles 28 and 29 by social policy or by other means than public interventions in the price setting for the supply of electricity."*[513] In line with findings of this thesis, the proposal thus suggests that prices need to be generally determined by the market in order to incentivise system users to adjust their energy and grid usage according to availabilities and related costs, and that protective measures need to be more nuanced and tailor-made. This trend is also reflected in the provision on universal service in the recast market directive 2019/--. The provision remains largely unchanged, only the definition of prices changed from "reasonable" to "competitive". The provision thus reads as follows

> *"Member States shall ensure that all household customers, and, where Member States deem it appropriate, small enterprises* […], *enjoy universal service, that is the right to be supplied with electricity of a specified quality within their territory at competitive [replaces "reasonable"] easily and clearly comparable, transparent and non-discriminatory prices."*[514]

The replacement is, however, curious when seen in relation to one of the main goals of the CEP that also is enabling "affordable" prices for consumers.[515] The question is,

510. Lea Diestelmeier, 'Changing Power: Shifting the Role of Electricity Consumers with Blockchain Technology – Policy Implications for EU Electricity Law' (2019) 128(special issue "Energy Law and Policy") Energy Policy 189-196.
511. See section 2.3.1 "In between Self-Responsibility and Protection".
512. Art. 5(1) recast market directive 2019/--.
513. Art. 5(2) recast market directive 2019/--.
514. Art. 27 recast market directive 2019/--.
515. Art. 1 recast market directive 2019/--.

whether competitive markets can ensure affordability, as affordability is not a self-evident concept in market based settings.[516] Yet again, this further suggests the dilemma between empowerment and protection and the need for the legal framework to balance both interests.[517]

Apart from the aim to strengthen market forces in the determination of supply prices, the recast market directive 2019/-- also includes a new title on the protection of consumers. Under the title "energy poverty" the directive requires members states to further develop and define the concept "energy poverty" by defining a set of criteria, *"which may include low income, high expenditure of disposable income on energy and poor energy efficiency"*.[518] Curiously, an earlier incorporated provision which required member states to report the evolution of energy poverty and preventive measures to the EU Commission has been removed in the most recent version of the legal text.[519] In light of findings of this thesis, energy poverty might be replaced by "flexibility poverty". Persons who cannot afford to invest in decentralised generation, home batteries, electric vehicles, or SHTs can simply not benefit as easily from dynamic prices as they are continuously exposed to all price fluctuations, thus also peak prices. "Flexibility poverty" might thus become a more severe issue than "energy poverty" which also connect to the foregoing issue of affordability.

One the one hand, the (recast) directives thus aim at steering towards furthering the market integration of consumers by providing them with access to relevant data on capacity related prices and enabling them to enter into more self-determined market transactions; on the other hand, the directive acknowledges that consumers remain in need of protective measures. The current recast market directive 2019/-- shows that the elaboration of both interests in a legal framework is complex and requires nuanced solutions which incentivise system users as market participants and yet ensures a sufficient degree of protection.

4.4 A Step towards a Legal Framework for Smart Electricity Systems?

While the CEP was not specifically developed with the ambition to further the development of SES, it does aim at shifting the focus of the energy transition towards decentralised solutions to accomplish the energy transition towards a low-carbon based sector. This mainly includes fostering decentral generation and demand-response at

516. Simone Pront-van Bommel, 'A Reasonable Price for Electricity' (2016) 39 Journal for Consumer Policy, 141-158, 151.
517. Lea Diestelmeier and Marlies Hesselman, 'De positie van huishoudelijke consumenten in het EU Winterpakket: Tussen participeren en beschermen' (2018) 1-2(special issue Winterpakket) Nederlands Tijdschrift voor Energierecht 31-40, 39.
518. Art. 29 recast market directive 2019/--.
519. Art. 29 recast market directive 23 February 2017.

distribution grid level and subsequent definitions of new actors. As stated above, in this development, the EU Commission perceives the integration of consumers in the electricity sector through "prosumers" (or as defined in the recast market directive 2019/-- "active customers") and "aggregators" as key to the attainment of the energy transition. The outset of this section illustrated this with quoting a key heading of the CEP, namely *"putting consumers at the heart of the energy market"* and subsequent reasoning why this is necessary (as for example, avoiding the need for "back-up" capacities). Regarding the development of SES, this shifted focus in the legislative proposal is generally a positive reformation, as these changes essentially acknowledge the demand-side as potentially "active" or "adjustable" part of the electricity supply chain.

However, more detailed insights in the recast market directive 2019/-- show that even though the need for activating more flexibility at all levels of the electricity supply chain is acknowledged and incorporated in the reformed or novel provisions, the incumbent rationale of the legal framework barely changes. Despite the fact that the proposal departs from the finding that technology offers new ways of organisation and thereby essentially suggests the relation between the technology component and the organisational component, the (recast) directives do not focus on the functionalities but remains with the approach of demarcated tasks of actors. For example, the definition of "consumer" is in an ideal SES setting not relevant anymore, as every system user could switch between being generator, consumer, and possibly contribute to system operation. Chapter 3 revealed that the convergence of flexibility technologies and the exchange of data via communication networks enable system users to react according to real-time cost-reflective prices. An adjusted definition of what "active customers" or "renewable self-consumer" could do does not capture the necessary legal changes for SES. The approach of the reformed directives is to capture all new phenomena (such as prosumers and self-consumption) in an exhaustive set of definitions. This thesis argues that this approach cannot be applied in decentralised, SES where a large variety of technologies applied. Instead, the rationale of the system functionalities needs to be decisive for the legal framework. System users are thus not defined by a legal definition which captures the "do's and don'ts" according to the incumbent supply chain structure, but are defined by their ability to contribute to the system functionalities, that is essentially their flexibility profile. Moreover, the electricity system has to include communication networks, smart meters, and the flexibility sources connected to the system in order to optimise the efficient usage of energy resources and grid capacities. Finally, the availability of flexibility technologies in combination with data on capacities and respective prices changes the ability of system users to enter into transactions, which are facilitated by automation.

Considering in particular the identified obstacles for the development of SES under the current legal framework (section 3 of this chapter, namely independent grid operation, access, consumer protection, and RES promotion), the reformed directives only partly resolve these issues. Regarding independent grid operation, the role of the DSOs remain central and, even though only as an exceptional possibility, might include flexibility provision which might risk unlocking the flexibility of various system users facilitating SES.[520] The issue of access to data is addressed as the recast market directive 2019/-- requires member states to implement smart metering systems and entitles final consumers to such systems. However, smart metering systems alone do not facilitate a SES. Parties need access to data in order to be able to participate in a SES. As mentioned, an earlier version of the recast directive specified a broad range of actors who would eligible parties to access data. The most recent version leaves more leniency to the member states in specifying eligible parties who may have access to data of final customers. This might possibly result in unequal market developments among member states depending on who has access to the data (eligible parties) and for which purposes. Regarding the current consumer protection framework of the electricity sector, the assumption is that consumers, household consumers and SMEs, are a homogenous group which therefore falls under one protection regime. SES functionalities potentially render this assumption invalid, as consumers will become a much more heterogeneous group, based on their flexibility profile, which determines their ability to gain from dynamic pricing (or not). While the recast market directive 2019/-- foresees market-based retail prices for small consumers, it does not in particular address the issue of differing abilities of consumers to gain from these prices. Instead of addressing "energy poverty", SES would require a legal framework which protects small consumers from negative consequences of "flexibility poverty". The legal framework on RES promotion under Directive 2018/2001 changed as the directive now establishes a Union-wide target. The favourable measure of priority access for RES is abolished, which acknowledges the need for a market-based integration of RES in the electricity system and the sector. This would also need to be reflected in support schemes by designing them not only to incentivise the generation of RES, but also the efficient use of the sources.

The findings of this thesis indicate that a legal framework for SES would need to be much more complex, as the abilities of system users and system operators amplify with SES functionalities. The introduction of this thesis stated that the working assumption of this research follows from the current legal framework, that is reducing monopolistic

520. Section 4.3.2 'Electricity Systems'.

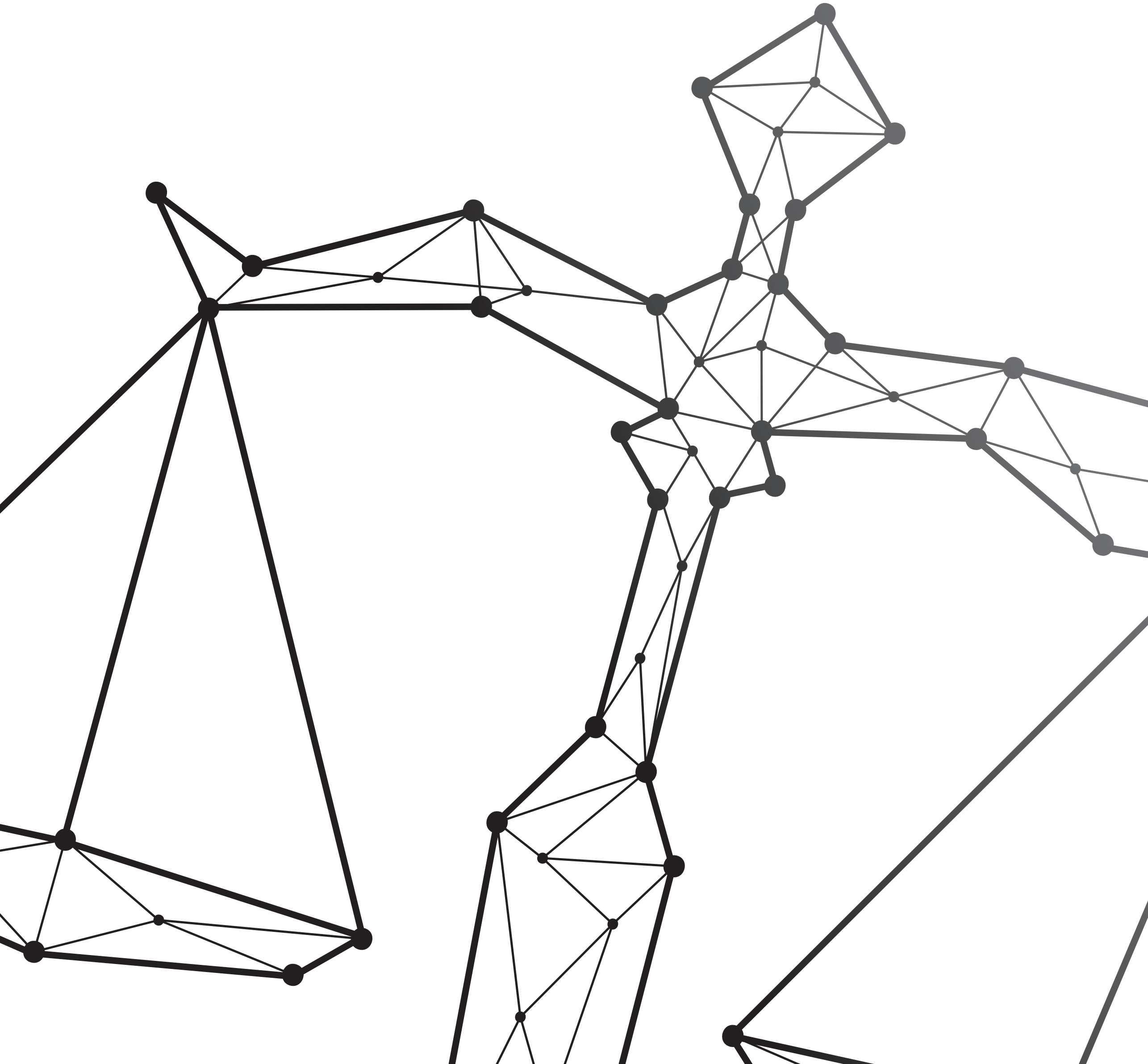
activities in the electricity sector.[521] This objective, however, needs to be refined in the light of the technical and economic characteristics of SES. This was undertaken in section 2 of this chapter, which identified the main elements for a legal framework along the changing role of system users, the electricity system, and interactions in the sector along SES functionalities. The approach of the CEP however remains mainly based on the rationale of the current legal framework.

5. CONCLUSION

This chapter related the main functionalities of SES to the role of system users, the system, and interactions in the electricity sector. The enhanced technical- and economic settings enabled by SES functionalities need to be reflected in the legal framework of the electricity sector. This chapter identified the main topics of such a legal framework and contrasted findings with the current legal framework and also ongoing legislative developments on EU level aiming to reform the electricity sector.

The findings of this chapter also further explain the chosen notion at the outset of this thesis: "smart electricity systems" instead of "smart grids" The technical functionalities of SES require shifting the understanding towards "reflective electricity systems".[522] This chapter showed that this observation goes beyond a mere terminological issue if translated to the legal framework. The "smart" in smart grids, essentially means a more efficient operation of the grid which is achieved by integrating demand flexibility. Inevitably, this changes the role of consumers towards market participants, extends the electricity system beyond the cable infrastructure and the meters, and substitutes intermediating entities by access to transparent real-time data enabling P2P transactions. The conclusion of this thesis further elaborates on these main findings and discusses implications for a legal framework.

521. Introduction, section 2.4 'Methodology and Approach'.
522. Section 2.4 "Synthesis: A Reflective Legal Framework for Reflective Systems".



CONCLUSION

1. INTRODUCTION

The introduction of this thesis set out from explaining the idea of SES as mainly technical and economic driven innovation.[523] The subsequent chapters kept the technical and the economic component of the electricity system as departing points for identifying implications for the legal framework of the electricity sector. In this way, this thesis aimed at showing that the development of SES cannot be furthered by asserting an exhaustive definition of SES, but that SES are complex and manifold systems which can better be understood by their ascribed goals and technical functionalities. This thesis thus identified those goals and technical functionalities and based thereon ascertained legal implications. The main findings regarding legal implications are categorised in the changing role of system users, the electricity system, and interactions enabled by SES functionalities.

The findings suggest that a legal framework which incentivises SES requires more than adding definitions or adjusting provisions in the current legal framework of the electricity sector. The current legal framework is tailored to a centralised "top-down" electricity sector. This thesis argued that SES functionalities require overhauling this setting. Therefore, instead of recommending corrections of the current legal framework, this thesis advocates to further investigate policy implications of a legal framework incentivising SES. Based on the findings of this thesis three major policy implications can be identified which relate to the changing role of system users, the system, and interactions. These policy implications are the following (and further elaborated in section 3 of this conclusion):

1. *From Categorised System Users to Flexibility Capabilities*
   SES functionalities change the role of categorised system users (producers and different consumers) to system user with different flexibility profiles determining their commercial ability to engage as independent market participants in the electricity sector. This requires dissolving categorised actor definitions as established by the current legal framework and incentivising flexibility.

2. *Electricity Systems Beyond Cables and Meters*
   SES functionalities potentially allow integrating all connected system users and electric devices (production, consumption, storage) for system operation. This extends the current understanding of the electricity system beyond the grid infrastructure by including communication infrastructures and further extends

523. See "Introduction", section 1.

beyond the meters of users by taking into account single devices for grid management. This requires enabling new services which not only focus on the supply of electricity, but offer enhancing the flexibility profile of system users.

3. *Technologies as Trust Substitutes*
SES functionalities require a transparent and rapid exchange of data on system capacities and respective prices among system users *inter se* and between system users and system operators. In this rapidly changing setting, system users cannot take every single decision of their market participation. This requires entrusting technologies with automation for SES market participation.

As these three points are very far-reaching consequences, this thesis concludes not by recommending selective point-by-point adjustments to current provisions in the legal framework, but elaborates on those points and identifies them as policy implications of a legal framework which enable and incentivises SES. Clearly, these policy implications require further investigation and research for the development of a legal framework in greater detail. In this view, this thesis can only provide findings which can be regarded as starting point requiring further research elaborating the main elements for a legal framework for SES in greater detail. Section 4 further reflects on the contribution of this thesis to the development of SES.

This concluding chapter unfolds in the following sections: section 2 answers the posed research questions. Based on the answers to the research questions, section 3 draws policy implications of a legal framework which incentivises SES. A final conclusion reflects on the findings and the policy implications for a legal framework and places this thesis in the context of developments in the energy sector and more specifically ongoing legislative processes at EU level. This final step relates the findings of this thesis to the “real world” and critically reflects on the contribution of this thesis for the development of SES.

2. ANSWERING THE RESEARCH QUESTIONS

This thesis aimed to answer the following main research question: *“which legal framework enables and incentivises smart electricity systems?”* The introduction of this thesis explained that at the core of this question is the relationship between technology and law in the electricity sector. Furthermore, the introduction stated that understanding this relationship requires going beyond mere legal science. From a legal perspective, the challenge is to not getting lost in the fascinating and endless world of technical details, but to understand technology to the extent it sophisticates the electricity system and subsequently renders the role of actors in the sector. This thesis comprises several sub research questions which consecutively lead to answer the main research question (chapter 1 – 4). The following sections specifically answers each of the posed research questions which further leads to the suggested policy implications for a legal framework incentivising SES (section 3).

2.1 The Role of Law in the Development of the Electricity System

Chapter 1 laid the cornerstone of this thesis by analysing the question *"what is the role of law in the development of the electricity sector?"* The chapter approached this question by outlining the development of the electricity sector and the role of law therein. The chapter argued that technology and law always stand in a reciprocal relation. In more recent decades and especially with the aim to establish an internal energy market in the EU and the aim to reduce carbon emissions from the sector law further developed as a shaping and steering component in the electricity sector. In turn, the aim to liberalise the sector and to reduce carbon emissions furthered the development of new technologies, especially small-scale generation on basis of RES and new actors, such as "prosumers", and changing demand patters (these developments were captured under the notion "electricity sector in flux") which now require new forms of organisation enabled by the legal framework.

2.2 The Rationale of Smart Electricity Systems and Constraints in Developing a Legal Framework

Chapter 2 related findings of chapter 1 to the development of SES and analysed the question *"what is the rationale behind the idea of SES and what are constraints in developing a legal framework for SES?"* To answer the question, the chapter applied the approach established in chapter 1 by relating the technical component of the electricity system to the main EU policy goals of the energy sector. In this way, the chapter refrained from definitional approaches of understanding SES and argued that the rationale of SES is given by the clash between technical constraints and major EU policy goals regarding the energy sector. The objectives ascribed to SES aim at reconciling what is often referred to as "energy trilemma". Based on first findings of the *Experimental Decree* under Dutch law, the chapter identified the main constraints in developing a legal framework for innovative solutions (for example SES) in the electricity sector. Findings of pilot projects are often condemned to remain within prior defined technologies actors and outcomes and therefore can only result in incremental knowledge generation. The chapter thus concludes that the development of a legal framework for SES requires more fundamental research establishing theoretical groundwork which enables extending beyond ever-incomplete technology listing and incumbent actor categories.

2.3 Theoretical Groundwork for Legal Framework for Smart Electricity Systems

Chapter 3 serves the quest of the previous chapter by answering the question *"which theoretical framework supports the development of a legal framework for SES?"* The chapter approaches this question by identifying the main technical functionalities of SES and argues that the functionalities enable a convergence of tasks which are under the current legal framework strictly assigned to actors along the network- and market realm division according to the rationale of a liberalised sector setting. Drawing analogies from the telecommunications sector, the chapter investigates the idea of technology-neutral and goal-oriented regulation as theoretical framework for the development of a legal framework of SES. The chapter argues that SES cannot be captured by exhaustive technology- and rule-based regulation because the technical functionalities allow for a variety of SES applications. Additionally, the need for exponential technological development cannot be hampered by technology-specific law. The chapter thus advocates for a goal-oriented technology-neutral legal framework for SES.

2.4 Elements of a Legal Framework for Smart Electricity Systems

Chapter 4 applies the findings of the previous chapters and investigates the question *"what are the main elements of a legal framework which enables and incentivises SES?"* In order to identify elements of a legal framework which is closely connected to the main technical functionalities, the chapter investigates how the technical functionalities of SES render the role of system users, the system, and interactions. The issues of legal framework for SES are identified along those categories of system users, system, and interactions. Regarding system users, a legal framework needs to establish incentives for system users to engage in flexibility. The use of the electricity system would thus need to be governed by dynamic tariffs designs and access to communication networks which are dedicated to SES purposes. Interactions among system users *inter se* and system users and system operators need to be based on real-time data, yet a safety-net for system users has to be in place. The identified elements are related to ongoing legislative processes on EU level aiming to reform the electricity sector. The chapter concludes that the identified elements for a legal framework for SES need more extensive changes in the legal framework than adjusting the current legal framework in selected points.

2.5 A Legal Framework for Smart Electricity Systems

The present conclusion compiles the results of the thesis and answers the main research question *"which legal framework enables and incentivises SES?"* Stemming from the main findings, especially of chapter 4 regarding the role of system users, the system, and interactions, this chapter suggests that a legal framework which incentivises SES requires more than selective point-by-point adjustments to the current legal framework. The rationale of the current legal framework is insufficient for the development of SES. This is not due to the overarching rationale to establish a liberalised internal electricity market, but due to the lacking incorporation of the technical and economic sophisticated options provided by SES functionalities. Essentially, SES functionalities even further the development of a liberalised electricity sector by extending the market realm and allowing for a more precise delineation between market- and network tasks. However, the current legal framework only knows a limited number of actors which are assigned tasks along the market-network divide. SES functionalities sophisticate this setting by enabling every system user and every device to engage in market-based interactions. This complexity cannot be captured by the current setting as established by the legal framework but requires novel rationales guiding the development of a legal framework which enables SES. The following section identifies those rationales as policy implications of a legal framework for SES.

3. POLICY IMPLICATIONS FOR A LEGAL FRAMEWORK INCENTIVISING SMART ELECTRICITY SYSTEMS

The previous section pinpointed the findings by answering the research questions posed at the outset of this thesis. The chapters consecutively led to answering the main research question, which legal framework enables and incentivises SES. The answer to this question revealed that a legal framework needs to be of technology-neutral and goal-oriented nature allowing the technical functionalities of SES to render the role of system users, the system, and interactions. Chapter 4 identified main topics relating to the role of system users, the system, and interactions which would need to be further developed in a legal framework for SES. While elaborating the exact details of such a legal framework would go beyond the scope of this thesis, this thesis identifies three major policy implications of a legal framework for SES. These implications are in the subsequent sections discussed for the changing role of system users, the system, and interactions.

3.1 System Users: From Categorised System Users to Flexibility Capabilities

This thesis identifies a shift from categorised system users to flexibility capabilities as one of the main policy implications of a legal framework for SES. The current legal framework of the EU electricity sector establishes governance structures which are based on clear-cut actor definitions along the top-down supply chain (from large scale generation to passive loads). A legal framework for SES would need to refrain from "one-size-fits-all" system user definitions (producers and consumers) and classify system users according to their capacities and capabilities to adjust their consumption and/or engage in production. Every system user would thus possess over a unique profile determining their commercial ability to engage in transactions. This would imply a policy shift from defining system users in two main homogenous group, producers and consumers, towards understanding them as market peers with different commercial abilities, namely their flexibility capabilities. Unlocking this flexibility of system users would have three major implications for the legal framework.

Firstly, unlocking flexibilities requires legal framework of the electricity sector to refrain from merely incentivising generation on basis of RES, but also establishing incentives for system users to invest in flexibility technologies. Responding to technical needs, the incentive scheme would need to be closely coordinated with local electricity system states, meaning system needs for lowering costs. For example, heavily congested parts of the electricity system determine incentives for investing in storage or other flexibility technologies, while in less congested areas RES production might be incentivised.

Secondly, the legal framework would need to establish dynamic pricing systems as default mechanisms which enable recouping investments under market conditions. This would extend the market realm of the sector by including demand flexibilities of system users who have been passive consumers so far. While this is in line with the role of consumers as envisaged by the EU Commission in the CEP, the recast market directive 2019/-- continues applying the actor-based approach by defining new categories, such as "active customers".[524] This fails thinking-through the idea of focusing on flexibility as a functionality which could ideally be offered by any system user. This would imply categorising system users along their flexibility profile. In this way, the legal framework could provide targeted incentives for system users with a high quality flexibility profile. To illustrate, system users with a higher quality in flexibility (timing and capacity) can react rapidly to price changes, while system users with low quality flexibility profiles are not able to do so and consequently exposed to a larger variety of price differences to their disadvantage.

This leads to the third major implication, the design of a protection framework for system users. System users with a lower flexibility profile are exposed to rapidly changing prices for electricity supply and transport. They bear the costs of the system, while system users with high flexibility profiles reap the benefits. This situation might lead to an undesired

524. Art. 2(6) Recast Market Directive.

social imbalance between those who can afford investments in flexibility technology and production installations and those who cannot afford such investments. However, the current protection framework for consumers assumes a homogenous group of small consumers (households and small and medium sized enterprises). This categorisation becomes useless regarding the aim to protect the weaker groups in the electricity sector. Flexibility is the key for system users to participate and to benefit from lower prices, it is thus not the amount of energy consumed which defines system users, but their ability to react to dynamic prices by means of flexibility technologies. This requires protecting "flexibility-poor" system users in the electricity sector.

3.2 Smart Electricity System: Electricity Systems beyond Cables and Meters

The integration of demand-side flexibility requires taking these flexibilities into consideration in distribution system planning and operation. This necessarily requires extending the understanding of the electricity system in the following two points: firstly, the flexibilities need to be communicated. SES are thus electricity systems which are enhanced with communication networks and smart meters. This requires the legal framework of the electricity sector to include the operation of communication networks and the provision of communication services which are dedicated to SES purposes. Secondly, the understanding of the electricity system needs to extend beyond the meters of the system users, as everything connected to the system can be considered for system operation. This requires a policy shift towards understanding the grid as infrastructure which not only serves the purpose of supplying and transporting electricity, but which offers a variety of services for communication and metering and for flexibility improvements to SES users. These two points have the following major implications for the legal framework of the electricity sector:

Firstly, system users can only engage in SES and offer their flexibility profile if they have access to communication networks which are dedicated to SES purposes. This requires establishing non-discriminatory access conditions to communication networks and smart metering systems. This would imply that operators of communication networks and providers of communication services need to be included in the legal framework for SES. Their tasks need to be clearly delineated from the tasks of system operators, yet they would need to coordinate and exchange data to coordinate the electricity system state and flexibility provision of system users.

Secondly, as argued above in section 3.1, the flexibility profile of system users is decisive for their ability to gain from dynamic prices. The market thus not only needs to focus on the provision of electricity as a product, but also on flexibility as a service. These services could vary according to location, capacities, and timing and complement the flexibility profile of the system user requesting a service. This also requires more sophisticated services for communication and metering as not only the consumed or produced electricity needs to be metered, but also demand flexibility of system users. Enabling those services for SES operations requires extending the market in the electricity sector. The legal framework for SES needs to establish an open and competitive market for flexibility services. Currently, the DSOs and the electricity supply companies are the main operators and providers in the electricity sector. New services however would not necessarily need to be assigned to their task packages. On the contrary, the variety of services allows for new business models and market actors to emerge. The legislative proposal of the EU Commission generally also foresees flexibility services, in particular identified as storage and electric vehicle charging, as market-based activities. Yet, the proposal leaves options for the DSO to engage in these activities if a competitive market remains absent. In order to avoid this problem, this thesis argues that the implementation of a legal framework for SES needs to address the changing role of system users, the system, and interactions jointly instead of making selective adjustments. This is in line with finding of the outset of this thesis illustrating the synergies among the components in the electricity system.

3.3 Interactions: Technologies as Trust-Substitutes

A technical precondition for SES to become viable is the availability and transparency of data on real-time costs on energy and grid tariffs for system users. Every system user connected to the network would need unrestricted and non-discriminatory access to the data for market-based transactions. This changes the approach from integrating consumers or prosumers into the market into enabling system users to form a market resulting in an increasingly decentralised organisation of the sector with a plethora of independent market participants. Inevitably, this results in a more diverse market which is not only dominated by conventional supply undertakings but also by individual system users or aggregators. The availability and transparency of data allows executing transactions by dynamic automation mechanisms relating to a predetermined price. Firstly, this implies a policy shift from central entities controlling transactions towards allowing technologies as trust-substitutes for transactions, thus enabling automation. Secondly, and related to section 3.1, this also implies understanding consumers as self-responsible market participants, who however yet require minimum standards of protection and additional tailor-made safety-net options.

Firstly, real-time, location dependent dynamic pricing requires automation of decision-making for system users engaging in SES. Furthermore, access to data for every system users could also enable P2P interactions. Automated P2P transactions instead of central handling through suppliers and system operators would imply a policy shift towards technologies substituting intermediating entities in data possession and processing. Online platforms, for example as the one deployed by the company “Vandebron”[525] would still need to be installed by a company, who is essentially a platform provider, their business however is thus not the retail and distribution of electricity, but the provision of the technology which then facilitates trust and subsequently transactions between peers. Currently, data and subsequent transactions are integrated with intermediating actors, the suppliers and system operators. The legal framework thus also assigns them with the related responsibilities of electricity supply and distribution. Organising these responsibilities in a decentralised sector with a great variety of system users contributing to supply and system operation becomes more complex. The system operator would need to contract flexibility for system operation with system users. System users would need to deliver the contracted flexibility and in case of non-compliance bear the costs of imbalances. Similarly, a decentralised model of electricity supply could lay down the responsibilities with the individual or aggregated system users. As these interactions would be based on the availability and exchange of data on dynamic prices of energy and grid capacities, technologies facilitating this exchange become the core of transactions.

Secondly, and as argued above in section 3.1, such a decentralised setting with an increased level of interaction facilitated by technologies also requires changing the current consumer protection regime towards a more individualised system. System users can still enjoy minimum universal requirements, but depending on their own capabilities of engaging in market based transactions require additional safety-net provisions. Yet again, this exemplifies that the technical functionalities of SES and their subsequent consequences on the role of system users, the system, and interactions cannot be analysed in isolation but stand in close interconnection. One of the main aims of this thesis was to understand this interconnection between technology and law in the electricity system and specifically for the case of SES.

All three implications (section 3.1, 3.2, 3.3) clearly entail a much more complex design of a legal framework for SES than the current legal framework. All points require a more detailed elaboration. Yet, this thesis contributed to the development of SES by identifying these points and assessing them against the background of the current legal framework and ongoing legal developments at EU level. The following, and final section further reflects on the contribution of this thesis to the development of SES.

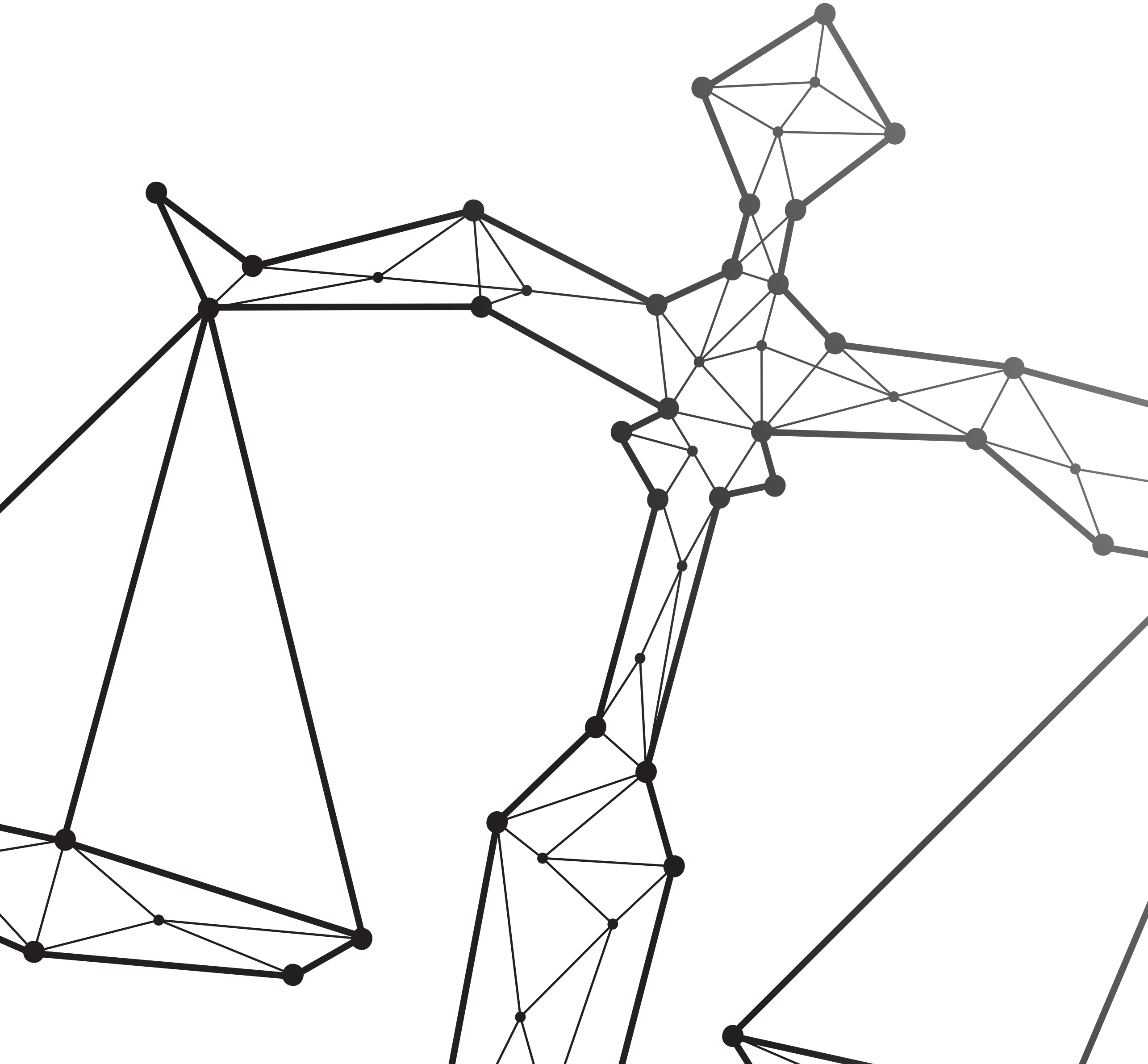
525. Chapter 4, section 2.3.1.1

4. LOOKING AHEAD: CONTRIBUTION OF THIS THESIS TO THE DEVELOPMENT OF SMART ELECTRICITY SYSTEMS

This thesis set out with the aim to investigate which legal framework enables and incentivises SES. This aim entailed two main challenges: setting the scope of the legal framework and the scope of SES. Attempting to accomplish these challenges, this thesis approached both challenges in close relation. Essentially, one of the main arguments throughout the thesis is that both need to be understood in a close reciprocal relation. Underlying this approach lays the opinion of the author that legal scholars have to extend beyond commenting on existing legislation in relation to a selected technology. Instead, the exercise of legal scholars should be to identify and analyse progressive subjects requiring innovative legal approaches and solutions. Only with a forward-looking mind can we accomplish a future that integrates technologies as supporting tools for a better society. As technologies develop, it is thus our task as legal scholars to think about hypotheses of future legal implications. In this way, this thesis aims at contributing to the development of SES, analysing progressive issues rather than identifying detailed impediments in existing legal provisions.

The energy sector and everything associated with it never stands still, it is always "in flux". During the time of conducting this research and writing this thesis much has happened in the energy sector and more specifically in legislative processes aiming at reforming EU energy sector legislation. One of the main conclusions of this thesis is that the current legal framework does not incentivise, or even enable, the implementation of SES. The legal reform of the electricity sector initiated by the EU Commission, the CEP, aims at facilitating the integration of demand flexibility and thus consumers as flexibility sources for system operation. Even though the proposal acknowledges many aspects which relate to SES and the idea to facilitate a more efficient electricity system, this thesis concludes that the rationale of the legal framework does not change and only partly facilitates the further development of SES. Therefore, this thesis further concludes by identifying three major policy implications which require additional research and elaboration. Yet, this thesis also acknowledges that legislative proposals are the outcome of negotiations taking place in a political arena with the influence of different stakeholders with varying interests. In that sense, the CEP might be starting point for a legal framework which enables and incentivises SES. As the electricity sector is always "in flux", new developments which might be enabled by the reformed EU legal framework and the implementation in national jurisdictions, again require observation and analysis from the perspective of different disciplines. Legal scholars can contribute thereto by striking the balance between on the one hand identifying and commenting on obstacles under existing legal frameworks and on the other hand analysing developments with an open mind and forward-looking ideas which are not restrained by the current legal setting. In this way, this thesis attempted to contribute to the development of SES.

C



BIBLIOGRAPHY

EU Legislation

Consolidated version of the Treaty on the Functioning of the European Union [26 October 2012] OJ C326.

Directive (EC) No 1996/92 Concerning Common Rules for the Internal Market in Electricity [1997] OJ L27/20.

Directive (EC) No 2001/77 on the Promotion of Electricity Produced from Renewable Energy Sources in the Internal Electricity Market [2001] OJ L283/27.

Directive (EC) No 2002/19 on Access to, and Interconnection of, Electronic Communications Networks and Associated Facilities [2002] OJ L 108/7.

Directive (EC) 2002/20/EC on the Authorisation of Electronic Communications Networks and Services [2002] OJ L 108/21

Directive (EC) No 2002/21 on a Common Regulatory Framework for Electronic Communications Networks and Services [2002] OJ L 108/33.

Directive (EC) No 2002/22 on Universal Service and Users' Rights relating to Electronic Communications Networks and Services [2002] OJ L 108/51.

Directive (EC) No 2003/54 Concerning Common Rules for the Internal Market in Electricity and repealing Directive 96/92/EC [2003] OJ L176/37.

Directive (EC) No 2003/87 Establishing a Scheme for Greenhouse Gas Emission Allowance Trading within the Community and amending Council Directive 96/61/EC [2003] OJ L275/32.

Directive (EC) No 2008/101 amending Directive 2003/87/EC so as to Include Aviation Activities in the Scheme for Greenhouse Gas Emission Allowance Trading within the Community [2009] OJ L8/3.

Directive (EC) No 2009/28 on the Promotion of the Use of Energy from Renewable Sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC [2009] OJ L140/16.

Directive (EC) No 2009/31 on the Geological Storage of Carbon Dioxide and amending Council Directive 85/337/EEC, European Parliament and Council Directives 2000/60/EC, 2001/80/EC, 2004/35/EC, 2006/12/EC, 2008/1/EC and Regulation (EC) No 1013/2006 [2009] OJ L140/114.

Directive (EC) No 2009/72 Concerning Common Rules for the Internal Market in Electricity and repealing Directive 2003/54/EC [2009] OJ L211/55.

Regulation (EC) No 2009/713 Establishing an Agency for the Cooperation of Energy Regulators [2009] OJ L211/1.

Regulation (EC) No 2009/714 on Conditions for Access to the Network for Cross-Border Exchanges in Electricity and repealing Regulation 2003/1228/EC [2009] OJ L211/15.

Directive (EU) No 2012/27 on Energy Efficiency, amending Directives 2009/125/EC and 2010/30/EU and repealing Directives 2004/8/EC and 2006/32/EC [2012] OJ L315/1.

Regulation (EU) No 2013/347 Guidelines for Trans-European Energy Infrastructure and repealing Decision 2006/1364/EC [2013] OJ L 115/39.

Regulation (EU) No 2013/1316 Establishing the Connecting Europe Facility, amending Regulation (EU) No 913/2010 and repealing Regulations (EC) No 680/2007 and (EC) No 67/2010 [2013] OJ 348/129.

Directive (EU) No 2018/2001 on the Promotion of the Use of Energy from Renewable Sources [2018] OJ L328/82.

EU Case Law

Case 6/64 Costa vs ENEL.

Case 393/92 Almelo and Others vs Energiebedrijf IJsselmij [1992] ECR I-01508.

Case 158/94 Commission v Italy [1994] ECR-I 05789.

Case 7/97 Oscar Bronner GmbH & Co. KG v Mediaprint Zeitungs- und Zeitschriftenverlag GmbH & Co. KG [1998] ECR I-07791.

Case 17/03 Vereniging voor Energie, Milieu en Water, Amsterdam Power Exchange Spotmarket BV, Eneco NV v Directeur van de Dienst uitvoering en toezicht energie [2005] ECR I-04983.

Case 439/06 Citiworks AG [2008] ECR I-03913.

Case 239-07 Julius Sabatauskas and Others [2008] ECR I-07523.

Case 366/10 Air Transport Association of America, American Airlines Inc., Continental Airlines Inc., United Airlines Inc. v Secretary of State for Energy and Climate Change ECR I-13755.

Case 573/12 Ålands Vindkraft AB v Energimyndigheten.

EU Official Documents

Commission of the EC, Completing the Internal Market: White Paper from the Commission to the European Council, COM(85)310, 28-29 June 1985.

Council of the EC, Concerning New Community Energy Policy Objectives for 1995 and Convergence of the Policies of the Member States, (86/C 241/01), 16 September 1986.

Commission of the EC, The Internal Energy Market – Commission Working Document, COM(88)238 final 2, May 1988.

Commission of the EC, Communication from the Commission to the Council on the Greenhouse Effect and the Community, establishing the Commission Work Programme concerning the Evaluation of Policy Evaluation to deal with the Greenhouse Effect and a Draft Resolution on the Greenhouse Effect and the Community COM(1988)656, 16 November 1988.

Commission of the EC, Communication from the Commission - Energy for the Future: Renewable Sources of Energy. White Paper for a Community Strategy and Action Plan COM(1997)599 final, 26 November 1997.

Commission of the EC "Green Paper on the Convergence of the Telecommunications, Media and Information Sectors, and the Implications for Regulation. Towards an Information Society Approach", COM(97)623 3 December 1997.

Commission of the EC "Towards a new framework for Electronic Communications Infrastructure and Associated Services. The 1999 Communications Review" COM(1999)539 10 November 1999.

Commission of the EC, Communication from the Commission to the Council and the European Parliament – Completing the Internal Energy Market – Proposal for a Directive amending Directives 96/92/EC and 98/30/EC concerning Common Rules for the Internal Market in Electricity and Natural Gas – Proposal for a Regulation on Conditions for Access to Network for Cross-Border Exchange in Electricity, COM(2001)125 final, 13 March 2001.

Commission of the EC, 'Communication of the Commission to the Council and the European Parliament, the share of renewable energy in the EU Commission Report in accordance with Article 3 of Directive 2001/77/EC, evaluation of the effect of legislative instruments and other Community policies on the development of the contribution of renewable energy sources in the EU and proposals for concrete actions', COM(2004)366.

Commission of the EC (2005), Technical Annex to the Report from the Commission to the Council and the European Parliament on Progress in Creating the Internal Gas and Electricity Market. COM (05)568 final. Brussels, 2005

Commission of the EC, Energy Sector Enquiry, SEC (2006) 1724, 10 January 2007.

Commission of the EC, Green Paper on a European Strategy for Sustainable, Competitive and Secure Energy, COM(2006) 105 final, 8 March 2006.

Commission of the EC, Communication on an Energy Policy for Europe, COM(2007) 1 final, 10 January 2007.

Commission of the EC, Renewable Energy Road Map Renewable Energies in the 21st Century: Building a more Sustainable Future COM(2006)848, 10 January 2007.

Commission of the EU, Communication on Europe 2020 - A Strategy for Smart, Sustainable and Inclusive Growth, COM(2010)2020 final, 3 March 2010.

Commission of the EU, Communication on Energy 2020: A Strategy for Competitive, Sustainable, and Secure Energy, COM(2010) 639 final, 10 November 2010.

Commission of the EU, Communication from the Commission. Smart Grids: From Innovation to Deployment. Brussels, 12 April 2011.

Commission of the EU, Energy Roadmap 2050, COM(2011)885 final, 15 December 2011.

Commission of the EU, Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions A Policy Framework for Climate and Energy in the Period from 2020 to 2030 COM(2014)15, 22 January 2014.

Commission of the EU, Communication on Energy Union Package - A Framework Strategy for a Resilient Energy Union with a Forward-Looking Climate Change Policy, COM(2015)80 final, 25.2.2015.

Commission of the EU, legislative proposal 'Clean Energy for All Europeans' 30 November 2016.

Commission of the EU, 'Renewable Energy Progress Report', COM(2017) 57 final, 1 February 2017.

Commission of the EU, Proposal for a Directive on Common Rules for the Internal Market in Electricity COM (2016) 864 final, 30 November 2016.
Commission of the EU, Proposal for a Directive on Common Rules for the Internal Market in Electricity (recast)-CORRIGENDUM-this document corrects document COM (2016) 864 final of 30 November 2016 (Brussels, 23 February 2017).
Council of the EU, Proposal for a Directive of the European Parliament and of the Council on the Promotion of the Use of Energy from Renewable Sources. Inter-institutional File 2016/0382 (COD) (Brussels 21 June 2018).
Commission of the EU, Proposal for a Directive of the European Parliament and of the Council on Common Rules for the Internal Market in Electricity (recast)- Analysis of the final compromise text with a view to agreement' Interinstitutional File: 2016/0380(COD), (Brussels, 11 January 2019).
European Parliament, Legislative Resolution of 26 March 2019 on the Proposal for a Directive of the European Parliament and of the Council on Common Rules for the Internal Market in Electricity (recast) (COM(2016)0864 – C8-0495/2016 –2016/0380(COD)), A8-0044/2018.

The Netherlands: Legislation and Official Documents

Elektriciteitswet 1998 Wet van 2 Juli 1998, houdende regels met betrekking tot de productie, het transport en de levering van elektriciteit, Stb. 1998, 427.
Besluit van 28 februari 2015, houdende het bij wege van experiment afwijken van de Elektriciteitswet 1998 voor decentrale opwekking van duurzame elektriciteit (Besluit experimenten decentrale duurzame elektriciteitsopwekking), Stb 2015, 99.
Energieakkord voor duurzame groei, Kamerstukken II 2012/13 30 196, nr. 202.

Journal Articles

Albadi A and El-Saadany E, 'A Summary of Demand Response in Electricity Markets' (2008) 78 Electric Power Systems Research 1989–1996.
Allcott H, 'Rethinking Real-Time Electricity Pricing' (2011) 33 Resource and Energy Economics 820-842.
Ancillotti E, Bruno R, and Conti M, 'The Role of Communication Systems in Smart Grids: Architectures, Technical Solutions and Research Challenges' (2013) 36 Computer Communications 1665-1697.
Antonsen S, Almklov P, Fenstad J, and Nybø A, 'Reliability Consequences of Liberalization in the Electricity Sector: Existing Research and Remaining Questions', (2010) 18(4) Journal of Contingencies and Crisis Management 208-219.
Arentsen M and Bellekom S, 'Power to the People: Local Energy Initiatives as Seedbeds of Innovation?' (2014) 4(2) Energy, Sustainability and Society 1-12.

Arentsen M and Künneke R, 'Economic Organization and Liberalization of the Electricity Industry' (1996) 24(6) Energy Policy 541-552.

Arghandeh R, Meier von A, Mehrmanesh L, and Mili L, 'On the Definition of Cyber-Physical Resilience in Power Systems' (2016) 58 Renewable and Sustainable Energy Review 1060-1069.

Asselt van H and Biermann F, 'European Emissions Trading and the International Competitiveness of Energy-Intensive Industries: a Legal and Political Evaluation of Possible Supporting Measures' (2007), 35(1) Energy Policy 497-506.

Auer H, Resch G, Haas R, Held A and Ragwitz M, 'Regulatory Instruments to deliver the Full Potential of Renewable Energy Sources Efficiently' (2009) 3(2) European Review of Energy Markets 1-34.

Baere de G and Ryngaert C, 'The ECJ's Judgment in Air Transport Association of America and the International Legal Context of the EU's Climate Change Policy' (2013) 18(3) European Foreign Affairs Review 389-409.

Batalla-Bejerano J and Trujillo-Baute E, 'Impacts of Intermittent Renewable Generation on Electricity System Costs' (2016) 94 Energy Policy 411-420.

Bell K and Gill S, 'Delivering a Highly Distributed Electricity System: Technical, Regulatory and Policy Challenges' (2018) 113 Energy Policy 765-777.

Bellekom S, Arentsen M, and van Gorkum K, 'Prosumption and the Distribution and Supply of Electricity' (2016) 6(22) Energy, Sustainability and Society 1-17.

Black J, 'Forms and Paradoxes of Principle-Based Regulation' (2008) 3(4) Capital Markets Law Journal 425-457.

Black J, Hopper M, and Band C, 'Making a Success of Principle-Based Regulation' (2007) 1 Law and Financial Markets Review 191-206.

Blaauwbroek N, Kuiken D, Nguyen P, Vedder H, Roggenkamp M, and Slootweg H, 'Distribution Network Monitoring: Interaction between EU Legal Conditions and State Estimation Accuracy' (2018) 115 Energy Policy 78–87.

Brown T, Faruqui A, and Grausz L, 'Efficient Tariff Structures for Distribution Network Services' (2015) 48 Economic Analysis and Policy 139-149.

Chen W, Zhou K, Yang S, and Wu C, 'Data Quality of Electricity Consumption Data in a Smart Grid Environment' (2017) 75 Renewable and Sustainable Energy Reviews 98-105.

Clastres C, 'Smart Grids: Another Step Towards Competition, Energy Security and Climate Change Objectives' (2011) 39 Energy Policy 5399-5408.

Cossent R, Tomás G, Frías P, 'Towards a Future with Large Penetration of Distributed Generation: Is the Current Regulation of Electricity Distribution Ready? Regulatory Recommendations under a European Perspective' (2009) 37 Energy Policy 1145-1155.

Daki H, El Hannani A, Aqqal A, Haidine A, and Dahbi A, 'Big Data Management in Smart Grid: Concepts, Requirements and Implementation' (2017) 4(13) Journal of Big Data 1-19.

Diestelmeier L, 'Changing Power: Shifting the Role of Electricity Consumers with Blockchain Technology – Policy Implications for EU Electricity Law' (2019) 128(special issue "Energy Law and Policy") Energy Policy 189-196.

Diestelmeier L and Hesselman M, 'De positie van huishoudelijke consumenten in het EU Winterpakket: Tussen participeren en beschermen' (2018) 1-2(special issue Winterpakket) Nederlands Tijdschrift voor Energierecht 31-40.

Diestelmeier L and Kuiken D, 'Smart Electricity Systems: Access Conditions for Household Customers Under EU Law' (2017) 1(1) European Competition and Regulatory Law Review 36-46.

Eid C, Codani P, Perez Y, Reneses J, and Hakvoort R, 'Managing Electric Flexibility from Distributed Resources: A Review of Incentives for Market Design' (2016) 64 Renewable and Sustainable Energy Reviews 237-247.

Eid C, Koliou E, Valles M, Reneses J, and Hakvoort R, 'Time-based Pricing and Electricity Demand-Response: Existing Barriers and Next Steps' (2016) 40 Utilities Policy 15-25.

Erlinghagen S, Lichtensteiger B, and Markard J, 'Smart Meter Communication Standards in Europe – a Comparison' (2015) 43 Renewable and Sustainable Energy Reviews 1249-1262.

Faerber L, Balta-Ozkan N, and Connor P, 'Innovative Network Pricing to Support the Transition to a Smart Grid in a Low-Carbon Economy' (2018) 116 Energy Policy 210-219.

Faruqui A, 'The Ethics of Dynamic Pricing' (2010) 23(6) The Electricity Journal 13-27.

Faruqui A, 'Arcturus: International Evidence on Dynamic Pricing' (2013) 26(7) The Electricity Journal 55-65.

Finon F and Pignon V, 'Electricity and Long-Term Capacity Adequacy: The Quest for Regulatory Mechanism Compatible with Electricity Market', (2008) 16 Utilities Policy 143-158.

Frenken F and Schor J, 'Putting the Sharing Economy in Perspective' (2017) (23)6 Environmental Innovation and Societal Transition 3-10.

Friedrichsen N, Brandstätt C, and Brunekreeft G, 'The Need for More Flexibility in the Regulation of Smart Grids – Stakeholder Involvement' (2014) International Economics and Economic Policy 11 261-275.

Gils H, 'Assessment of Theoretical Demand Response Potential in Europe' (2014) 67 Energy 1-18.

Giordano G and Fulli G, 'A Business Case for Smart Grid Technologies: A Systemic Perspective' (2012) 40 Energy Policy 252-259.

Greenberg B, 'Rethinking Technology Neutrality' (2015) 100(4) Minnesota Law Review 1495-1562.

Hahn H, Meyer-Nieberg S, and Pickl S, 'Electric Load Forecasting Methods: Tools for Decision Making' (2009) 199(3) European Journal of Operational Research 902-907.

Hary N, Rious V, and Saguan M, 'The Electricity Generation Adequacy Problem: Assessing Dynamic Effects of Capacity Remuneration Mechanisms' (2016) 91 Energy Policy 113-127.

He X, Keyaerts N, Azevedo I, Meeus L, Hancher L, and Glachant J, 'How to Engage Consumers in Demand Response: A Contract Perspective' (2013) 27 Utilities Policy 108 – 122.

Heffron R, McCauley D, and Sovacool B, 'Resolving Society's Energy Trilemma through the Energy Justice Metric' (2015) 87 Energy Policy 168-176.

Heldeweg, M 'Experimental Legislation concerning Technological & Governance Innovation – an Analytical Approach' (2015) The Theory and Practice of Legislation 169-193.

Hildebrandt M and Tielemans L, 'Data Protection by Design and Technology Neutral Law' (2013) 29 Computer Law & Security Review 509-521.

Hirth L and Ziegenhagen I, 'Balancing Power and Variable Renewables: Three Links' (2015) 50 Renewable and Sustainable Energy Reviews 1035-1051.

Hossain M, Madlool N, Rahim N, Selvaraj J, Pandey A, and Faheem Khan A, 'Role of Smart Grid in Renewable Energy: An Overview' (2016) 60 Renewable and Sustainable Energy Reviews 1168-1184.

Huhta K, 'Prioritising Energy Efficiency and Demand Side Measures over Capacity Mechanisms under EU Energy Law' (2017) 35(1) Journal of Energy & Natural Resources 7-24.

Jamasb T and Pollitt M, 'Electricity Market reform in the European Union: Review of Progress towards Liberalization & Integration', (2005) 26(special issue: European Electricity Liberalization) The Energy Journal 11-41.

Jamasb T and Pollitt M, 'Security of Supply and Regulation of Energy Networks' (2008) 36 Energy Policy 4584-4589.

Joode de J, Janse J, Welle van der A, Scheepers M, 'Increasing Penetration of Renewable and Distributed Electricity Generation and the Need for different Network Regulation', (2009) 37 Energy Policy 2907-2915.

Joode de, Jeroen, Jansen, J, Welle van der, A and Scheepers, M, 'Increasing Penetration of Renewable and Distributed Electricity Generation and the Need for Different Network Regulation'(2009) 37 Energy Policy 2907-2915.

Khalilpour R and Vassalo A, 'Leaving the Grid: An Ambition or a Real Choice?' (2015) 82 Energy Policy 207-221.

Klessmann C, Lamers P, Ragwitz M, and Resch G, 'Design Options for Cooperation Mechanisms under the New European Renewable Energy Directive' (2010) 38(8) Energy Policy 4679-4689.

Koenders H and Pipping S, 'Het Besluit experimenten decentrale duurzame elektriciteitsopwekking doorgelicht' (2016) 4/2016 Nederlands Tijdschrift voor Energierecht 146-155.

Kruimer H, 'Non-Discriminatory Energy System Operation: What Does It Mean?' (2011) 3 Competition and Regulation in Network Industries 260-286.

Kubik M, Coker P, and Hunt C, 'The Role of Conventional Generation in Managing Variability' (2012) 50 Energy Policy 253-260.

Künneke R and Fens T, 'Ownership Unbundling in Electricity Distribution: The Case of the Netherlands', (2007) 35 Energy Policy 1920-1930.

Lammers I and Diestelmeier L, 'Experimenting with Law and Governance for Decentralized Electricity Systems: Adjusting Regulation to Reality?' (2017) Sustainability 9(2) 212 1-14.

Lavrijssen S, 'Independent Supervisory Authorities: A Fragile Concept' (2012) 39(4) Legal issues of Economic Integration 419-446.

Lavrijssen S, 'Power to the Energy Consumers' (2017) European Energy and Environmental Law Review 172-187.

B

Lavrijssen S, and Hancher L, 'Networks on Track: From European Regulatory Networks to European Regulatory "Network Agencies" ' (2008) 34(1) Legal Issues of Economic Integration 23-55.

Lopes Ferreira H, Costescu A, L'Abbate A, Minnebo P, and Fulli G, 'Distributed Generation and Distributed Market Diversity in Europe', (2011) 39 Energy Policy 5561-5571.

Lund H, 'Renewable Energy Strategies for Sustainable Development' (2007) 32 Energy 912-919.

Lund P, Lindgren J, Mikkola J, and Salpakari J, 'Review of Energy System Flexibility Measures to Enable High Levels of Variable Renewable Electricity' (2015) 45 Renewable Energy and Sustainable Energy Reviews 785-807.

Meeus L, Purchala K, and Belmans R, 'Development of the Internal Electricity Market in Europe' (2005) 18(6) The Electricity Journal 25-35.

Molyneaux L, Wagner L, Froome C, and Foster J, 'Resilience in Electricity Systems: A Comparative Analysis' (2012) 47 Energy Policy 188.

Moura P, López G, Moreno J, and Almeida de A, 'The Role of Smart Grids to foster Energy Efficiency' (2013) 6 Energy Efficiency 621–639.

Neidhöfer G, '50-Hz frequency – How the Standard Emerged from a European Jumble' (2011) 9(4) Power and Energy Magazine 66-81.

Nijhuis M, Gibescu M, and Cobben S, 'Analysis of Reflectivity & Predictability of Electricity Network Tariff Structures for Household Consumers' (2017) 109 Energy Policy 631-641.

O'Brien G and Hope, A, 'Localism and Energy: Negotiating Approaches to Embedding Resilience in Energy Systems' (2010) 38 Energy Policy 7550-7558.

O'Brien G, 'Vulnerability and Resilience in the European Energy System' (2009) 20(3) Energy and Environment 399-410.

Oliver J and Sovacool B, 'The Energy Trilemma and the Smart Grid: Implications Beyond the United States' (2017) 4(1) Asia & Pacific Policy Studies 70-84.

Papaefthymiou G, and Dragoon K, 'Towards 100% Renewable Energy Systems: Uncapping Power System Flexibility' (2016) 92 Energy Policy 69-82.

Passey R, Haghdadi N, Bruce A, and MacGill I, 'Designing More Cost Reflective Electricity Network Tariffs with Demand Charges' (2017) 109 Energy Policy 642-649.

Passey R, Spooner T, MacGill I, Watt M, Syngellakis K, 'The Potential Impacts of Grid-connected Distributed Generation and how to address them: A review of Technical and Non-technical Factors' (2011) 39 Energy Policy 6280-6290.

Pereira G, Specht J, Pereira Silva P, and Madlener R, 'Technology, Business Model, and Market Design Adaptation Toward Smart Electricity Distribution: Insights for Policy Making' (2018) 121 Energy Policy 426-440.

Picciariello A, Reneses J, Frias P, and Söder L, 'Distributed Generation and Distributed Pricing: Why Do We Need New Tariff Design Methodologies?'(2015) 119 Electric Power System Research 370-376.

Pocklington P, 'European Emission Trading – The Business Perspective' (2002) 11(7) European Energy and Environmental Law Review 209-218.

Poudineh, R and Jamasb T, 'Distributed Generation, Storage, Demand Response and Energy Efficiency as Alternative to grid Capacity Enhancement' (2014) 67 Energy Policy 222-231.

Pudjianto D, Djapic P, Aunedi M, Kim Gan C, Strbac G, Huang S, and Infield D, 'Smart Control for Minimizing Distribution Network Reinforcement Cost due to Electrification' (2013) 52 Energy Policy 76-84.

Ranaweera D, Karady G, and Farmer R, 'Economic Impact Analysis of Load Forecasting' (1997) 12(3) IEEE Transactions on Power Systems 1388-1392.

Reeds C, 'Taking Sides on Technology Neutrality" (September 2007) 4(3) Script-ed, 263-284.

Rodrígues Ortega M, Pérez-Arriaga I, Rivier Abbad J, and Peco González J, 'Distribution Network Tariffs: A Closed Question?' (2008) 36 Energy Policy 1712-1725.

Ropenus S, Klinge Jacobsen H, Schröder S, 'Network Regulation and Support Schemes – How Policy Interactions affect the Integration of Distributed Generation' (2011) 36(7) Renewable Energy 1949-1956.

Rowlands I, 'The European Directive on Renewable Electricity: Conflicts and Compromises' (2005) 33 Energy Policy 965-974.

Ruester S, Schwenen S, Batlle C, and Pérez-Arriaga I, 'From Distribution Networks to Smart Distribution Systems: Rethinking the Regulation of European Electricity DSOs' (2014) 31 Utilities Policy 229-237.

Schleicher Tappeser R, 'How Renewables will Change Electricity Markets in the Next Five Years' (2012) 48 Energy Policy 64-75.

Schreiber M, Wainstein M, Hochloff P, and Dargaville R, 'Flexible Electricity Tariffs: Power and Energy Price Signals Designed for a Smarter Grid' (2015) 93 Energy 2568-2581.

Shariat Torbaghana S, Blaauwbroek N, Kuiken D, Gibescu M, Hajighasemi M, Nguyen P, Smit G, Roggenkamp M, Hurink J, 'A Market-Based Framework for Demand Side Flexibility Scheduling and Dispatching' (2018) 14 Sustainable Energy, Grids and Networks 47-61.

Shaw R, Attree M, Jackson T, and Kay M, 'The Value of Reducing Distribution Losses by Domestic Load-Shifting: A Network Perspective' (2009), 37 Energy Policy 3159-3167.

Stram B, 'Key Challenges to Expanding Renewable Energy' (2016) 96 Energy Policy 728-734.

Strbac G, 'Demand Side Management: Benefits and Challenges' 2008 36(12) Energy Policy 4419-4426.

Szydlo M, 'How to reconcile National Support for Renewable Energy with Internal Market Obligations? The Task for the EU Legislature after Ålands Vindkraft and Essent' (2015) 52(2) Common Market Law Review 489-510.

Tsado Y, Lund D, and Gamagea K, 'Resilient Communication for Smart Grid Ubiquitous Sensor Network: State of the Art and Prospects for Next Generation' (2015) 71 Computer Communications 34-49.

Vedder H, 'De Regulering van Smart Grids – Naar Slimmere, Functionelere of vooral Complexere Regelgeving?' (2011)2 Nederlandse Tijdschrift voor Energierecht 68-80.

Verbong G, Beemsterboer S, and Sengers F, 'Smart Grids or Smart Users? Involving Users in Developing a Low Carbon Electricity Economy' (2013) 52 Energy Policy 117-125.

Weibelzahl M, 'Nodal, Zonal, or Uniform Electricity Pricing: How to deal with Network Congestion' (2017) 11(2) Frontiers in Energy 210-232.

Welle van der A and Joode de J, 'Regulatory Road Maps for the Integration of Intermittent Electricity Generation: Methodology Development and the Case of The Netherlands'(2011) Energy Policy 39 5829-5839.

Wen F, Wu F, Ni Y, 'Generation Capacity Adequacy in the Competitive Electricity Market Environment' (2004) 26 International Journal of Electrical and Power Energy Systems 365-372.

Westerman P, 'Arguing about Goals: The Diminishing Scope of Legal Reasoning' (2010) 24(2) Argumentation 211–226.

Westerman P, 'Breaking the Circle: Goal-Legislation and the Need for Empirical Research' (2013) 1(3) The Theory and Practice of Legislation 395-414.

Westerman P, 'Who is Regulating the Self? Self-Regulation as Outsourced Rule-Making' (2010) 4(3) Legisprudence 225-241.

Wilson C, Hargreaves T, and Hauxwill-Baldwin R, 'Benefits and Risks of Smart Home Technologies' (2017) 103 Energy Policy 72-83.

Books and Book Chapters

Ahner N, 'The New Renewables Framework for Europe: Implementing Directive 2009/28/EC' in Martha Roggenkamp and Ulf Hammer (eds) *European Energy Law Report, VIII* (Intersentia Energy & Law Series 12 2011) 93-116.

Banet C, 'The Paris Agreement to the UNFCCC: Underlying Dynamics and Expected Consequences for the Energy Sector' in Martha Roggenkamp and Catherine Banet (eds) *European Energy Law Report XI* (Energy & Law Series Intersentia 2017) 71-91.

Banet C, 'Prosumer Legislation in Norway: A First Step for Empowering Small Energy Consumers' in Martha Roggenkamp and Catherine Banet (eds) *European Energy Law Report XII* (Intersentia Energy & Law Series 2018) 169-189.

Beaulieu A, 'What Are Smart Grids? Epistemology, Interdisciplinarity and Getting Things Done' in Anne Beaulieu, Jaap de Wilde, and Jaquelien Scherpen (eds.), *Smart Grids from a Global Perspective: Bridging Old and New Energy Systems* (Springer 2016) 63-73.

Bel N and Vermeeren R, 'Unbundling in the EU Energy Sector – The Commission's Practice in Assessing the Independence of Transmission System Operators for Electricity and Gas' in Martha Roggenkamp and Henrik Bjørnebye (eds) *European Energy & Law Report X* (Energy & Law Series 8 Intersentia 2014) 49-64.

Bergman, L, 'Addressing Market Power and Industry Restructuring' in Jean-Michel Glachant and François Lévêque (eds) *Electricity Reform in Europe – Towards a Single Energy Market* (Edwards Elgar Publishing 2009) 65-88.

Birnie P, Boyle A, and Redgwell C, *International Law and the Environment,* (3rd edn Oxford University Press 2009).

Cosic A, Diestelmeier L, Maxim A, Anh Nguye T, and Rosesetto N, 'Does Public Ownership provide Affordable and Reliable Electricity to Household Customers? Case Studies of Electricity Sector Reforms in the UK, France, Germany, and Italy' in Massimo Florio (ed) *The Reform of Network Industries – Evaluating Privatisation, Regulation, and Liberalisation in the EU* (Edward Elgar Publishing 2017) 139-156.

Depledge J and Yamin F, 'The Global Climate Change Regime – A Defence' in Dieter Helm and Cameron Hepburn (eds) *The Economics and Politics of Climate Change* (Oxford University Press 2009).

Diestelmeier L and Kuiken D, 'Legal Framework for Prosumers in the Netherlands' in Martha Roggenkamp and Catherine Banet (eds) *European Energy Law Report XII* (Intersentia Energy & Law Series 2018) 151-167.

Dobinson, I and Johns F, 'Legal Research as Qualitative Research' in Mike McConville and Wing Hong Chui (eds) *Research Methods for Law* (Edinburgh University Press 2017) 18-47.

Dodds P and Garvey S, 'The Role of Energy Storage in Low-Carbon Energy Systems' in Trevor Letcher (ed) *Storing Energy* (Elsevier 2016) 3-22.

Dralle T, 'The Unbundling and Unbundling-Related Measures in the EU Energy Sector' in *Ownership Unbundling and Related Measures in the EU Energy Sector European Yearbook of International Economic Law 5* (Springer 2018) 21-63.

Ehlers E, *Electricity and Gas Supply Network Unbundling in Germany, Great Britain and The Netherlands and the Law of the European Union: A Comparison* (Energy & Law Series 9 Intersentia 2010).

Enequist A, *From Abstract Goals to Concrete Rules: Regulating Nursing Home Care in Sweden and the Netherlands* (Dissertation University of Groningen 2015).

Feinberg E and Genethliou D, 'Load Forecasting' in Joe Chow, Felix Wu, and James Momoh (eds) *Applied Mathematics for Restructured Electric Power Systems – Optimization, Control, and Computational Intelligence* (Springer 2005) 269-285.

Fischer W (ed), *Die Geschichte der Stromversorgung* (Verlags- und Wirtschaftsgesellschaft der Elektrizitätswerke m.b.H 1992).

Guayo del I and Pielow J, 'Electricity and Gas Infrastructure Planning in the European Union' in Martha Roggenkamp, Lila Barrera-Hernández, Donald Zillman, and Inigo Del Guayo (eds) *Energy Networks and the Law* (Oxford University Press, 2012) 353-370.

Haar, van der I, *The Principle of Technological Neutrality: Connecting EC Network and Content Regulation* (Dissertation University of Tilburg, 2008).

Heldeweg and Evisa Kica (eds) *Regulating Technological Innovation – A Multidisciplinary Approach* (Palgrave 2011).

Heldeweg M, 'Legal Design of Smart Rules & Regimes: Regulating Innovation' in Michiel Heldeweg and Evisa Kica (eds) *Regulating Technological Innovation – A Multidisciplinary Approach* (Palgrave 2011) 37-53.

Hughes T, *Networks of Power: Electrification in Western Society, 1880-1930* (Johns Hopkins University Press 1983).

Keyhani A, *Design of Smart Power Grid Renewable Energy Systems* (John Wiley & Sons Inc 2011).

Johnston J, 'Peer-to-Peer Energy Matching: Transparency, Choice, and Local Grid Pricing' in Fereidoon Sioshansi (ed) *Innovation and Disruption at the Grid's Edge* (Elsevier Academic Press 2017) 319-330.

Knops H, *A Functional Legal Design for Reliable Electricity Supply – How Technology Affects Law* (Intersentia Energy & Law Series 6 2008).

Koops B, 'Should ICT Regulation be Technology-Neutral?' in Bert-Jaap Koops, Miriam Lips, Corien Prins, and Maurice Schellekens (eds) *Starting Points for ICT Regulation. Deconstructing Prevalent Policy One-Liners* (T.M.C. Asser Press IT & Law Series Vol. 9, The Hague 2006).

Kotlowski A, 'Access Rights to European Energy Networks – A Construction Site Revisited' in Bram Delvaux, Michaël Hunt and Kim Talus (eds) *EU Energy Law and Policy Issues – ELRF Collection*, (2nd edn Intersentia 2009).

Kruimer H, *The Non-Discrimination Obligation of Energy Network Operators – European Rules and Regulatory Practice* (Intersentia Energy & Law Series 15 2013).

Kulovesi K, 'Climate Change in EU External Relations: Please Follow My Example (or I might Force You to)' in Elisa Morgera (ed) *The External Environmental Policy of the European Union* (Cambridge University Press 2012).

Lakatos A, 'Overview of the Regulatory Environment for Trade in Electricity' in Janusz Bielecki, Melaku Desta (eds) *'Electricity Trade in Europe – Review of the Economic and Regulatory Challenges'* (Kluwer Law International 2004) 119-154.

Lammers I, *Rules for Watt? Designing Appropriate Governance Arrangements for the Introduction of Smart Grids*, (Dissertation University of Twente 2018).

Lang M, 'Prosumer Legislation in Germany' in Martha Roggenkamp and Catherine Banet (eds) *European Energy Law Report XII* (Intersentia Energy & Law Series 2018) 135-149.

Langendijk V, *Electrifying Europe – The Power of Europe in the Construction of Electricity Networks* (Aksant Academic Publishers Amsterdam 2008).

Maes T, 'The Energy Regulators' Core Competence: Network Tariff Setting', (2012) in in Bram Delvaux, Michaël Hunt and Kim Talus (eds) *EU Energy Law and Policy Issues - ELRF Collection* (Intersentia 2011).

Metz L, Midttun A, and Thomas S, 'Restructuring Electricity Systems in Transition' in Atle Midttun (ed), *European Electricity Systems in Transition* (Elsevier Global Energy Policy and Economics Series 1997).

Midttun A (ed), *European Electricity Systems in Transition. A comparative Analysis of Policy and Regulation in Western Europe* (Elsevier Global Energy Policy and Economics Series 1997).

Milaj-Weishaar J, *Surveillance with Non-Purpose Built Technology – Challenges for the Protection of the Right to Privacy in the European Union* (Dissertation University of Groningen, 2017).

Moel S de, and Melchior F, 'Cooperation Between TSOs: Background, Organisation and Netcodes' in Martha Roggenkamp and Ulf Hammer (eds) European Energy law report VIII (Energy & Law Series 12 Intersentia 2011) 21-42.

Mulder M, 'Economic Regulation of Energy Networks' in in Anne Beaulieu, Jaap de Wilde, and Jaquelien Scherpen (eds) *Smart Grids from a Global Perspective: Bridging Old and New Energy Systems* (Springer 2016) 113-126.

Nihoul P and Peter Rodford, *EU Electronic Communications Law: Competition and Regulation in the European Telecommunications Market* (2nd edn, Oxford University Press 2011).

Orton F, Nelson T, Pierce M, and Chappel T, 'Access Rights and Consumer Protections in a Distributed Energy System' in Fereidoon Sioshansi (ed) *Innovation and Disruption at the Grid's Edge* (Elsevier Academic Press 2017) 261-287.

Pansini A, *Guide to Electrical Power Distribution Systems* (6th edn, Fairmont Press 2005).

Pansinsi A, *Power Transmission and Distribution* (2nd edn, Fairmont Press 2005).

Patterson W, *Transforming Electricity* (The Royal Institute of International Affairs 1999).

Peeters M and Deketelaere K (eds) *EU Climate Change Policy: The Challenge of New Regulatory Initiatives* (Edward Elgar Publishing 2006).

Rønne A, 'Smart Grids and Intelligent Energy Systems: A European Perspective', in Martha Roggenkamp, Lila Barrera-Hernández, Donald Zillman, and Iñigo del Guayo (eds) *Energy Networks and the Law: Innovative Solutions* (Oxford University Press 2012) 141-160.

Roggenkamp M, 'Full Transparency through Ownership Unbundling: Ownership Unbundling of Transmission and Distribution Grids in The Netherlands' in Martha Roggenkamp and Ulf Hammer (eds) *European Energy law Report VI* (Energy & Law Series 8 Intersentia 2009) 61-76.

Roggenkamp M, 'Netherlands' in Martha Roggenkamp, Catherine Redgwell, Anita Rønne, and Iñigo del Guayo (eds) in *Energy Law in Europe – National, EU and International Regulation* (Oxford University Press 2016) 725-806.

Schlabbach J and Rofalski K, *Power System Engineering: Planning, Design and Operation of Power Systems and Equipment* (2nd edn Wiley-VHC Verlag, 2014).

Swanson C, 'The Agency for Cooperation of Energy Regulators' in Martha Roggenkamp and Ulf Hammer (eds) *European Energy law Report VI* (Energy & Law Series 8 Intersentia 2009) 37-50.

Toffler A, *The Third Wave* (Bantam Books, 1980).

Varley C, and Lammers G, (International Energy Agency) *Electricity Market Reform* (OECD/IEA 1999).

Vedder H, 'Competition in the EU Energy Sector – an Overview of Developments in 2009 and 2010' in Martha Roggenkamp and Ulf Hammer (eds), '*European Energy Law Report VIII*' (Intersentia Energy & Law Series 12 2011) 3-20.

Vedder H, 'The Formalities and Substance of EU External Environmental Competence: Stuck between Climate Change and Competitiveness' in Elisa Morgera (ed) *The External Environmental Policy of the European Union* (Cambridge University Press 2012).

Vedder H, Anita Rønne, Martha Roggenkamp, and Iñigo del Guayo, 'EU Energy Law' in Martha Roggenkamp, Catherine Redgwell, Anita Rønne, and Iñigo del Guayo (eds) *Energy Law in Europe – National, EU and International Regulation* (Oxford University Press 2016), 187-366.

Viscusi K, Vernon J, and Harrington J, *Economics of Regulation and Antitrust.* (2nd edn MIT Press 2005).

Walden I, 'European Union Communications Law' in Ian Walden (ed) *Telecommunications Law and Regulation* (4th ed Oxford University Press 2012).

Conference Papers and Working Papers

Aiello M and Pagani G, 'The Smart Grid's Data Generating Potentials' (2014) Proceedings of the 2014 Federated Conference on Computer Science and Information Systems 9-16. <https://annals-csis.org/Volume_2/pliks/509.pdf> accessed 6 May 2019.

Clarizia F, Gallo D, Landi C, Luiso M, and Rinaldi R, 'Smart Metering Systems for Smart Grid Management' (2016) Instrumentation and Measurement Technology Conference Proceedings, Institute of Electrical and Electronics Engineers, 23 – 26 May 2016.

Eid C, Codani P, Cheng Y, Perez Y, and Hakvoort R, 'Aggregation of Demand Side Flexibility in a Smart Grid: A Review for European Market Design' (2015), EEM15 – 12th International Conference on the European Energy Market, 20-22 May 2015. <https://hal.archives-ouvertes.fr/hal-01230914/document> accessed 6 May 2019.

Friedlund M, and Maier H, 'The Second Battle of the Currents – A Comparative Study of Engineering Nationalism in German and Swedish Electric Power, 1921-1961' (1996) TRITA-HST Working Paper 96/2.

Haar, van der I, 'Technology Neutrality: What Does It Entail?' (10 May 2007) SSRN <https://papers.ssrn.com/sol3/papers.cfm?abstract_id=985260> accessed 6 May 2019.

Kruimer H, 'Non-Discriminatory Energy System Operation: Lessons learned from Telecommunications and Public Procurement' (2011) Fourth Annual Conference on Competition and Regulation in Network Industries.

Larouche P, 'Communications Convergence and Public Service Broadcasting' (2 November 2005) SSRN <https://papers.ssrn.com/sol3/papers.cfm?abstract_id=832444> accessed 6 May 2019.

Rebours Y and Kirschen D, 'What is Spinning Reserve?' University of Manchester (19 September 2005). <https://www.researchgate.net/publication/228364081_What_is_spinning_reserve> accessed 6 May 2019.

Sakhrani V and Parsons J, 'Electricity Network tariff Architectures – A Comparison of four OECD Countries', (10 July 2010) Massachusetts Institute for Technology, Center for Energy and Environmental Policy Research (CEEPR) No. 10-008. SSRN. <https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1711198> accessed 9 February 2016.

Verbong G, Vleuten, van der E, and Scheepers M, 'Long-Term Electricity Supply System Dynamics – A Historic Analysis' (2002) Sustelnet Eindhoven (ECN-C—02-084). <https://publicaties.ecn.nl/PdfFetch.aspx?nr=ECN-C--02-084> accessed 6 May 2019.

Reports and News

ACER, 'ACER/CEER - Annual Report on the Results of Monitoring the Internal Electricity and Natural Gas Markets in 2017 – Electricity and Gas Retail Markets Volume' (22 October 2018). at <https://www.acer.europa.eu/Official_documents/Acts_of_the_Agency/Publication/MMR%202017%20-%20RETAIL.pdf> accessed 23 January 2019

CENLEC (1988). Harmonization Document HD 472 S1.

Commission of the EU, 'Study on Tariff Design for Distribution Systems' 28 January 2015. <https://ec.europa.eu/energy/sites/ener/files/documents/20150313%20Tariff%20report%20fina_revREF-E.PDF> accessed 24 January 2019.

Commission of the EU, Joint Research Centre, 'Smart Grid Projects Outlook' (2011, 2012, 2014, 2017). <https://ses.jrc.ec.europa.eu/smart-grids-observatory> accessed 6 May 2019.

Commission of the EU, Joint Research Centre, 'Demand Response Status in EU Member States' (2016). <http://publications.jrc.ec.europa.eu/repository/bitstream/JRC101191/ldna27998enn.pdf> accessed 6 May 2019.

Commission of the EU, Second Consumer Market Study on the Functioning of the Retail Electricity Markets for Consumers in the EU, September 2016. <http://ec.europa.eu/newsroom/just/item-detail.cfm?item_id=53331> accessed 6 May 2019.

Commission of the EU, 'Study on "Residential Prosumers in the European Energy Union" (2 May 2017), JUST/2015/CONS/FW/C006/0127 Framework Contract EAHC/2013/CP/04. <https://ec.europa.eu/commission/sites/beta-political/files/study-residential-prosumers-energy-union_en.pdf> accessed 6 May 2019.

Ecofys (2013). Incentives to Improve Energy Efficiency in EU Grids. By order of European Copper Institute 15 April 2013. <https://www.scribd.com/document/141626807/Grids-Paper-on-EU> accessed 6 May 2019.

Ecofys (2014), Flexibility Options in Electricity Systems, Berlin. <https://www.ourenergypolicy.org/wp-content/uploads/2014/06/Ecofys.pdf> accessed 6 May 2019.

ENTSO-E (2015), UCPTE/UCTE The 50 Year Success Story – Evolution of a European Interconnected Grid. <https://www.entsoe.eu/fileadmin/user_upload/_library/publications/ce/110422_UCPTE-UCTE_The50yearSuccessStory.pdf> accessed 6 May 2019.

European Environment Agency, 'Renewable Energy in Europe — 2018 – Recent Growth and Knock-on Effects' No 20/2018. <https://www.eea.europa.eu/publications/renewable-energy-in-europe-2018> accessed 30 January 2019

Frenken F, Meelen T, Arets M, and van de Glind P, 'Smarter Regulation for the Sharing Economy' Guardian (20 May 2015). <https://www.theguardian.com/science/political-science/2015/may/20/smarter-regulation-for-the-sharing-economy>accessed 6 May 2019

Heffner G, 'Smart Grid – Smart Customer Policy Needs' (2011) International Energy Agency 517-524. <https://www.iea.org/publications/freepublications/publication/sg_cust_pol.pdf> accessed 6 May 2019.

International Energy Agency (2011). Technology Roadmaps: Smart Grids. <https://www.iea.org/publications/freepublications/publication/smartgrids_roadmap.pdf> accessed 6 May 2019.

Kolokathis C and Hogan M, 'New Research: Europe's Electricity Networks are Underused and can cope with Electric Cars' (13 April 2018) Energy Post. <http://energypost.eu/new-research-europes-electricity-networks-are-underused-and-have-ample-capacity-to-cope-with-electrification-of-cars/> accessed 6 May 2019.

Kolokathis C, Hogan M, and Jahn A, 'Cleaner, Smarter, Cheaper: Network Tariff Design for a Smart Future', (2018) Regulatory Assistance Project. <https://www.raponline.org/knowledge-center/cleaner-smarter-cheaper-network-tariff-design-for-a-smart-future/> accessed 6 May 2019.

Shandorkova I, Bremdal B, Bacher R, Ottensen S, and Nilsen A, 'A Prosumer Oriented Energy Market. Developments and future outlooks for Smart Grid oriented energy markets' (2012) (Improsume Publication Series 2012).

United Nations, World Commission on Environment and Development, Report of the World Commission on Environment and Development: Our Common Future, United Nations Documents. <http://www.un-documents.net/our-common-future.pdf> accessed 16.2.2016

Weber A, Beckers T, Behr P, Bieschke N, Fehner S, and Hirschhausen von C, 'Long-Term Power System Planning in the Context of Changing Policy Objectives – Conceptual Issues and Selected Evidence from Europe' (Smart Energy for Europe Platform, Workgroup for Infrastructure Policy, Berlin University of Technology 2013). <http://www.sefep.eu/activities/publications-1/SEFEP_grid%20planning_June2013.pdf> accessed 6 May 2019.

World Energy Council, 'World Energy Trilemma Index 2018". <https://trilemma.worldenergy.org/reports/main/2018/2018%20Energy%20Trilemma%20Index.pdf> accessed 21 January 2019.

Websites

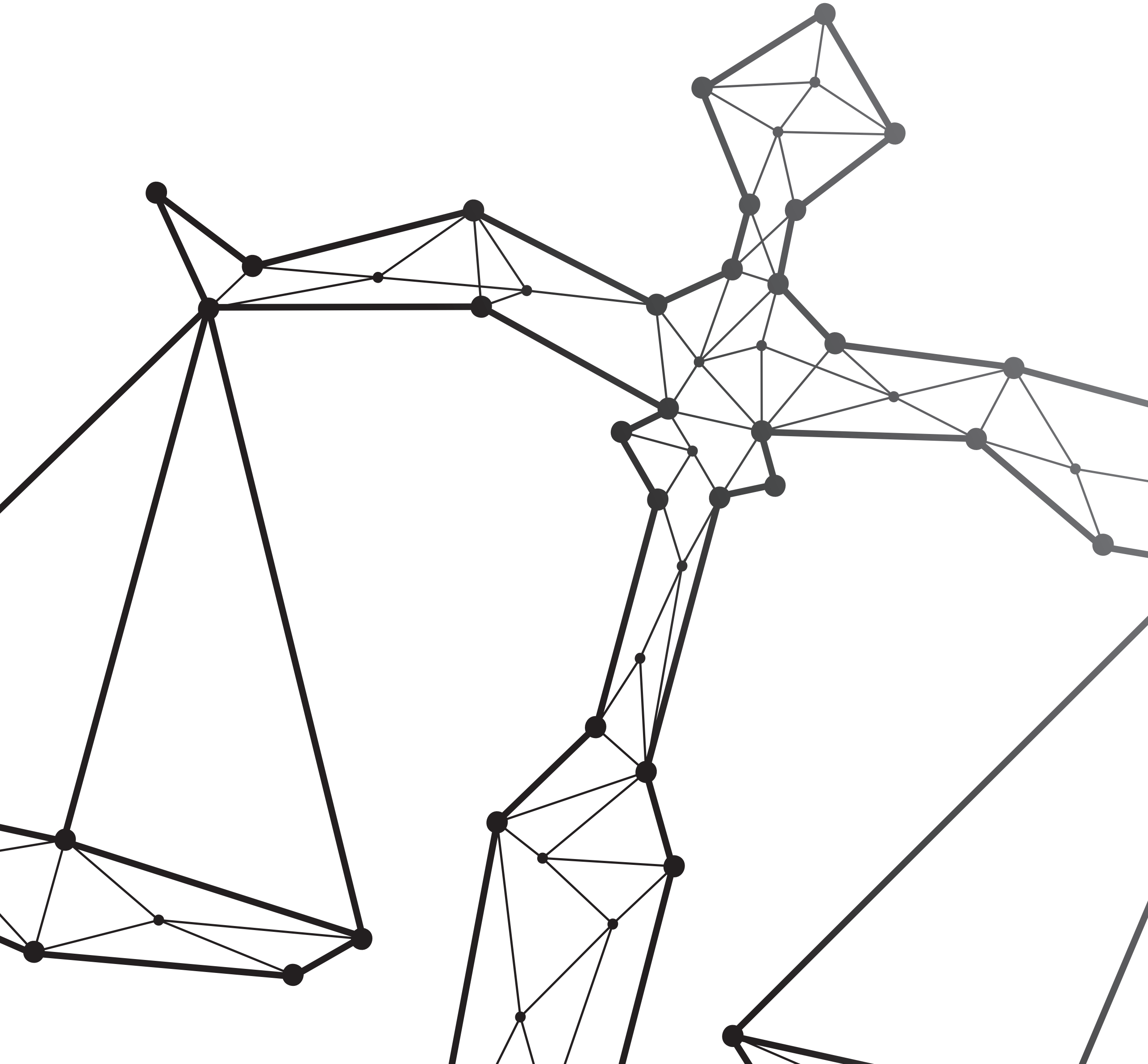
European Commission, '2020 Energy Strategy'. <https://ec.europa.eu/energy/en/topics/energy-strategy-and-energy-union/2020-energy-strategy> accessed 19 January 2019.

European Environment Agency, Greenhouse Gas – Data Viewer. <https://www.eea.europa.eu/data-and-maps/data/data-viewers/greenhouse-gases-viewer> accessed 19 January 2019.

Intergovernmental Panel on Climate Change, Global warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty. <https://www.ipcc.ch/sr15/> accessed 19 January 2019.

The Netherlands Organisation for Scientific Research, URSES project. <https://www.nwo.nl/onderzoek-en-resultaten/programmas/uncertainty+reduction+in+smart+energy+systems+(URSES)> accessed 6 May 2019.

United Nations Framework Convention on Climate Change. <https://unfccc.int/> accessed 6 May 2019.



APPENDICES

ENGLISH SUMMARY

In the European Union (EU), the shift towards increasing amounts of renewable energy sources (RES) is considered necessary as a measure to mitigate climate change and to reduce fuel dependency from third states. However, facilitating the integration of RES in the electricity system presents other challenges related to the variable character of RES. Large peaks would need to be captured by reinforced grid infrastructure, and generation dips would need to be balanced with conventional energy sources. Smart grids, or as this thesis poses smart electricity systems (SES), provide another approach to this challenge, namely by integrating flexibilities of consumers for better matching the variable generation of RES with electricity demand. While SES can thus be considered to be primarily driven by technology and economic efficiency objectives, this PhD thesis argues that SES also have implications for the legal framework of the electricity sector. *Vice versa,* and this is core to this thesis, making SES viable even requires the legal framework to be geared towards the functionalities of SES.

The overall aim of this PhD thesis is improving the knowledge on implications for a legal framework which enables and incentivises SES with a focus on the role of actors in the sector. Therefore, the main research question which this thesis seeks to answer is which legal framework enables and incentivises SES. As SES are driven by technology and economic efficiency objectives, this thesis cannot be undertaken as a purely legal research, but needs to be carried out at the cross-roads of various disciplines, more specifically, technology, economics and public administration. To answer the research question, this thesis builds upon existing research which established the "function-based legal design & analysis" method (FULDA method). Essentially, this method departs from the identification of the necessary technical functions of the electricity system and provides a decisions-making tool for the legal organisation of specific functions. The FULDA method provides a valuable approach for categorising the electricity sector into two main components, namely technology and organisation. The organisational component is further composed of economics and law. Along these components, this PhD thesis identifies the main functionalities of SES and develops a legal framework. The working assumption is that in a liberalised framework, monopolistic activities should be minimised and barriers to entry to the market should be as low as possible. This working assumption follows from the current legal framework, but may need to be refined in the light of the technical and economic characteristics of SES. This feedback-relation between the assumptions underlying the current legal framework and the characteristics of SES is the essential complexity that is identified and analysed in this thesis. The scope of this thesis entails the EU electricity sector and therefore mainly refers

A

to EU legislation when mentioning the “legal framework”, more specifically, legislation which governs the establishment of the internal electricity market and defines the roles and responsibilities of actors in the sector.

This PhD thesis consist of four chapters which all discuss and analyse at their core the relation between the technology- and the organisational component of the electricity sector.

Chapter 1 starts by describing the development of the electricity sector in general, and in particular analyses the role of law therein. In the recent decades, two main policy objectives which have been initiated on European level are shaping the electricity sector, namely the establishment of an internal energy market (IEM) and the aim to create a low-carbon based energy society. Both objectives materialised in legislation forming the legal framework of the electricity sector. The chapter also identifies new developments, which are summarised as “the electricity sector in flux” (decentral generation, prosumption, and demand flexibility). These emerging realities suggest that actors in the electricity sector do not necessarily fit anymore the established legal definitions and subsequent provisions, therefore, the chapter concludes that the current legal framework is likely to become increasingly meaningless or even an obstacle for the further development of the electricity sector.

Chapter 2 links the developments which are characterised as the “electricity sector in flux” with the need to develop SES. It does so by explaining the triangle (or trilemma) of policy goals of the EU electricity sector, namely adequacy, affordability, and sustainability. Maintaining these policy objectives in the “electricity sector in flux” becomes even more difficult as the technical options and actors in the electricity sector multiply. This requires new forms of coordination and cost-distribution of electricity system usage which might be facilitated by SES. Therefore, policy makers and scientists consider SES to be essential for a modern electricity system. The chapter identifies that these claims are often substantiated by relating SES to specific objectives. The main objectives are improving energy efficiency, integrating variable RES, maintaining grid resilience and facilitating system user centricity. The complexity of developing a legal framework for SES is illustrated by an example of an attempt to innovate the legal framework of the electricity sector in the Netherlands. This example shows that pilot projects and experimental spaces can only provide insights in the implementation of prior selected technologies and actors yielding narrow results. This chapter concludes that developing a legal framework which consolidates a specific design of the electricity sector depends on the policy goals and actors taken into consideration when developing that legal framework.

Chapter 3 operationalises the SES objectives outlined in chapter 2 by identifying main SES functionalities, which are flexibility, communication networks, and data. The chapter argues that SES are multifaceted systems which require a legal framework that is based on the main technical functionalities of SES. Therefore, this PhD thesis does not aim at asserting a general and complete definition of SES, but argues that there can be no single definition, rather a range of understanding of elements which can be included in SES and which are necessary for a defined goal. In that sense, the specified goal becomes of greater relevance than the specific technology deployed. Based on this finding, the chapter establishes theoretical groundwork for the development of a legal framework for SES, namely a technology-neutral, goal-oriented legal framework. Accordingly, this PhD thesis does not analyse singled out SES technologies but aims at understanding the changes that come along with SES technical functionalities in a more fundamental way. The chapter poses that the technical functionalities of SES change the role of system users, the electricity system, and interaction among system users and between system users and system operators in the following ways:

Currently, system users are defined in two main categories, producers and consumers. Flexibility technologies, communication networks, and availability of real-time data render them into market participants who cannot be distinguished by a predetermined category, but by their ability and willingness to react to dynamic prices, their flexibility-profile.

The technical functionalities of SES extend the understanding of the electricity system beyond the grid assets (from the point of production to the metering point) by adding communication networks for data exchanges to the system and by taking into account flexibility technologies behind the meter of system users.

Interactions are currently facilitated by suppliers and system operators who connect producers and consumers. Access to information enable system users to engage in self-determined market transactions. This amplifies the number and type of interactions actors and diversifies the services by focusing on efficiency gains and thus flexibility of system users.

Chapter 4 develops a legal framework for SES by identifying key elements resulting from the changing role of system users, the electricity system, and interactions in the SES scenario and relates those findings to the current and recently reformed EU legal framework of the energy sector. The chapter argues that a legal framework organised along system users, the system, and interactions needs to incorporate three main points:

1. Incentivise system users to invest in- and use flexibility technologies by including dynamic pricing and the option of aggregating demand-side flexibilities
2. Establish efficiency gains as the core maxim for system operations in distribution network tariffs and non-discriminatory access provisions for SES infrastructure
3. Enable interactions based on data autonomy among system users and between system users and system operators and provide a safety-net for reliable electricity supply.

Based on these elements for a legal framework for SES, the chapter identifies obstacles under the current legal framework regarding system operation, access conditions, consumer protection, and RES promotion. The chapter also analyses the legislative proposal of the EU Commission, "Clean Energy for All Europeans", more specifically, Directive 2018/2001 on the promotion of RES and the recast electricity market directive, against the background of the findings of this PhD thesis. While the chapter acknowledges that the legal reform generally places demand-flexibility and system users more central, it concludes that the reformed directives only partly resolve the obstacles for the development of SES which have been identified under the current legal framework.

The findings suggest that a legal framework which incentivises SES requires more than adding definitions or adjusting provisions in the current legal framework of the electricity sector. The PhD thesis concludes by identifying three main policy implications of a legal framework for SES regarding the shift of categorised system users towards flexibility capabilities, the operation of the electricity system beyond cables and meters, and data-based interactions. Each implication has far-reaching consequences for the rationale of the current legal framework of the electricity sector requiring further research.

NEDERLANDSE SAMENVATTING

In de Europese Unie (EU) wordt de transitie naar steeds meer hernieuwbare energiebronnen noodzakelijk geacht als een maatregel om de klimaatverandering te beperken en de afhankelijkheid van brandstoffen uit derde landen te verminderen. Het groeiende aandeel van hernieuwbare energiebronnen in het elektriciteitssysteem brengt echter andere uitdagingen met zich mee. Deze uitdagingen worden met name veroorzaakt door het variabele karakter van hernieuwbare energiebronnen zoals zon en wind. Bij deze bronnen is de beschikbaarheid lastig te controleren.

In de huidige praktijk wordt het opgestelde vermogen van hernieuwbare elektriciteit uitgerold op basis van piekvermogens. Deze pieken moeten worden opgevangen door het elektriciteitssysteem, hetgeen veelal forse investeringen in de huidige netwerkinfrastructuur betekend om de pieken op te vangen. Tegenover deze pieken staan ook dalen, welke dan weer zouden moeten worden gecompenseerd met conventionele energiebronnen zoals gas- of kolengestookte elektriciteitscentrales. Slimme netten, of zo als dit proefschrift stelt slimme elektriciteitssystemen (SES), bieden een andere oplossing voor het verwerken van de door hernieuwbare elektriciteit gegenereerde pieken en dalen (variabele opwekking). Om de variabele opwekking van elektriciteit uit hernieuwbare energiebronnen beter af te stemmen op de vraag naar elektriciteit, integreren SES de (potentiele) flexibiliteit van consumenten in het (slimme) elektriciteitssysteem. Voorgaande houdt zoveel in dat consumenten met behulp van technische oplossingen hun installaties middels (handels)platformen kunnen laten inspelen op het beschikbaar vermogen op een specifiek moment. Hoewel SES dus in eerste instantie beschouwd kunnen worden als een technologische- en economische ontwikkeling om efficiëntiedoelstellingen te bereiken, stelt dit proefschrift dat SES ook gevolgen hebben voor het juridisch kader voor de elektriciteitssector. Vice versa -en dit is de kern van dit proefschrift, is het noodzakelijk dat het juridisch kader wordt afgestemd op de functionaliteiten van SES.

Het overkoepelende doel van dit proefschrift is het bijdragen aan de kennisbasis omtrent de implicaties van een wettelijk kader dat SES mogelijk maakt, in het bijzonder met betrekking tot de rol van actoren in de elektriciteitssector. De belangrijkste onderzoeksvraag die dit proefschrift adresseert is dus welk wettelijk kader SES mogelijk maken en aanmoedigen. Aangezien SES gedreven zijn door doelstellingen op het gebied van technologie en economische efficiëntie, kan het onderzoek dat aan dit proefschrift ten grondslag ligt niet louter als een juridisch onderzoek worden beschouwd. Dit onderzoek is uitgevoerd op het raakvlak van verschillende disciplines, in het bijzonder technologie, economie en bestuurskunde. Om de onderzoeksvraag te beantwoorden,

A

bouwt dit proefschrift voort op bestaand onderzoek waaruit de *"function-based legal design & analysis"* methode (FULDA methode) is ontsproten. De FULDA methode begint met het identificeren van noodzakelijke technische functies in het elektriciteitssysteem en gaat uit van de functies die ten grondslag liggen aan het ontwerp van de juridische inrichting van de sector. De FULDA methode biedt een waardevolle benadering voor de indeling van de elektriciteitssector in twee hoofdcomponenten, namelijk technologie en organisatie. De organisatorische component bestaat verder uit economie en recht.

Op basis van deze componenten worden in dit proefschrift de belangrijkste functies van SES in kaart gebracht en een juridisch kader ontwikkeld. Het uitgangsprincipe is dat in een geliberaliseerde (energie) sector monopolistische activiteiten tot een minimum moeten worden beperkt en dat belemmeringen voor toegang tot de markt zoveel mogelijk moeten worden beperkt. Dit uitgangspunt vloeit voort uit het huidige wettelijke kader, maar moet wellicht worden aangescherpt in het licht van de technische en economische mogelijkheden geboden door SES. Deze aanscherping is noodzakelijk op basis van de discrepantie tussen de aannames die ten grondslag liggen aan het huidige rechtskader en de kenmerken van SES en is hoofdzakelijk dé complexiteit die in dit proefschrift wordt vastgesteld en geanalyseerd. De reikwijdte van dit proefschrift ziet op de elektriciteitssector in de EU en verwijst daarom ook vooral naar EU-wetgeving wanneer het "wettelijk kader" (*legal framework*) wordt genoemd, met name de wetgeving die de totstandbrenging van de interne elektriciteitsmarkt regelt.

Het proefschrift bestaat uit vier hoofdstukken die in de kern allen de relatie tussen het technologie- en organisatiecomponent van de elektriciteitssector bespreken en analyseren.

Hoofdstuk 1 begint met een beschrijving van de ontwikkeling van de elektriciteitssector in het algemeen en analyseert in het bijzonder de rol van het recht daarin. In de afgelopen decennia zijn twee belangrijke EU beleidsdoelstellingen vorm gegeven binnen de elektriciteitssector, namelijk de totstandbrenging van een interne energiemarkt (IEM) en de doelstelling om het aandeel hernieuwbare energiebronnen drastisch te verhogen. Beide doelstellingen werden geconcretiseerd in wetgeving die het rechtskader van de elektriciteitssector vormt. Het hoofdstuk identificeert ook nieuwe ontwikkelingen, die samengevat worden als *"the electricity in flux"* (decentrale opwekking, *prosumption* en *demand flexibility*). Deze nieuwe ontwikkelingen wijzen erop dat de actoren in de elektriciteitssector niet noodzakelijkerwijs meer te vangen zijn in de vastgestelde wettelijke definities en bepalingen. Daarom wordt in het hoofdstuk geconcludeerd dat het huidige wettelijke kader steeds minder betekenis zal krijgen of zelfs een belemmering zal vormen voor de verdere ontwikkeling van de elektriciteitssector en SES.

Hoofdstuk 2 koppelt de ontwikkelingen die worden gekenmerkt als de *"electricity sector in flux"* aan de noodzaak om een SES te ontwikkelen. Dit wordt gedaan aan de hand van 'het trilemma' tussen de beleidsdoelstellingen van de EU-elektriciteitssector, namelijk toereikendheid, betaalbaarheid en duurzaamheid (*adequacy, affordability, sustainability*). Het behouden van deze beleidsdoelstellingen in de *"electricity sector in flux"* wordt (nog) moeilijker naarmate de technische opties en actoren in de elektriciteitssector zich vermenigvuldigen. Dit vereist nieuwe vormen van coördinatie en kostenverdeling van het gebruik van het elektriciteitssysteem, welke door SES kunnen worden gefaciliteerd. Daarom achten beleidsmakers en wetenschappers SES essentieel voor een modern elektriciteitssysteem. In het hoofdstuk wordt aangegeven dat deze stellingen vaak worden onderbouwd door SES te relateren aan specifieke doelstellingen. De voornaamste doelstellingen zijn het verbeteren van de energie efficiëntie, het integreren van variabele hernieuwbare energiebronnen, het behoud van netwerk *resilience* en het centraliseren van de systeemgebruikers. De complexiteit van de ontwikkeling van een juridisch kader voor SES wordt geïllustreerd door een voorbeeld in Nederland, waar de nodige initiatieven zijn ondernomen om het juridisch kader van de elektriciteitssector te innoveren. Dit voorbeeld toont aan dat pilotprojecten en experimentele ruimtes alleen inzicht kunnen geven in de implementatie van vooraf geselecteerde technologieën en actoren en daardoor slechts beperkte resultaten kunnen opleveren. In dit hoofdstuk wordt geconcludeerd dat de ontwikkeling van een juridisch kader dat een specifiek ontwerp van de elektriciteitssector consolideert, afhankelijk is van de beleidsdoelstellingen en de actoren waarmee rekening wordt gehouden bij de ontwikkeling van dat juridisch kader.

Gebaseerd op de in hoofdstuk 2 beschreven doelstellingen van SES worden in hoofdstuk 3 de belangrijkste functies van SES vastgesteld, te weten flexibiliteit, communicatiemiddelen en data. In hoofdstuk 3 wordt betoogd dat SES veelzijdige systemen zijn die een wettelijk kader vereisen dat gebaseerd is op de belangrijkste technische functionaliteiten van SES. Het doel van dit proefschrift is dan ook niet om een algemene en volledige definitie van SES vast te stellen, maar stelt dat er niet één enkele definitie kan worden gegeven, maar dat er veeleer sprake kan zijn van een reeks inzichten in de elementen die in SES kunnen worden opgenomen en die noodzakelijk zijn voor een bepaald doel. In die zin wordt het gestelde doel van groter belang dan de specifieke technologie die wordt ingezet. Op basis van deze bevinding wordt in dit hoofdstuk een theoretische basis gelegd voor de ontwikkeling van een juridisch

A

kader voor SES, namelijk een technologieneutraal, doelgericht juridisch kader. Dit proefschrift analyseert dan ook niet de specifieke technologieën van SES, maar beoogt de veranderingen die gepaard gaan met de technische functionaliteiten van SES op een meer fundamentele manier te begrijpen. Het hoofdstuk stelt dat de technische functionaliteiten van SES de rol van de systeemgebruikers, het elektriciteitssysteem en de interactie tussen de systeemgebruikers onderling en tussen de systeemgebruikers en de netbeheerders op de volgende manieren veranderen:

- Tegenwoordig worden de gebruikers van het systeem gedefinieerd in twee hoofdcategorieën: producenten en consumenten. Flexibiliteitstechnologieën, communicatiemiddelen en de beschikbaarheid van real-time data maken ze tot marktdeelnemers die zich niet onderscheiden door een vooraf bepaalde categorie, maar door hun vermogen en bereidheid om te reageren op dynamische prijzen, hun flexibiliteitsprofiel.
- De technische functionaliteiten van SES maken het begrip van het elektriciteitssysteem breder dan alleen het net (van het productiepunt tot het meetpunt) door communicatienetwerken voor data-uitwisseling aan het systeem toe te voegen en door rekening te houden met flexibele technologieën achter de meter van de systeemgebruikers.
- Interacties worden momenteel gefaciliteerd door leveranciers en systeembeheerders die producenten en consumenten met elkaar verbinden. Toegang tot informatie zou systeemgebruikers in staat stellen om zelf bepaalde markttransacties uit te voeren. Dit vergroot het aantal en het type interacties tussen de actoren en diversifieert de diensten door zich te richten op efficiëntiewinst en dus flexibiliteit van de systeemgebruikers.

In hoofdstuk 4 wordt een juridisch raamwerk voor SES ontwikkeld door de belangrijkste elementen te identificeren die voortvloeien uit de veranderende rol van de systeemgebruikers, het elektriciteitssysteem en de interacties in het SES scenario. Vervolgens worden deze bevindingen in verband gebracht met het huidige en onlangs hervormde rechtskader van de energiesector in de EU. In het hoofdstuk wordt betoogd dat een wettelijk kader dat is georganiseerd op basis van systeemgebruikers, het systeem en interacties, drie hoofdpunten moet omvatten:

1. Systeemgebruikers moeten ertoe worden aangezet te investeren in- en gebruik te maken van- flexibele technologieën door dynamische prijsstelling en de mogelijkheid om de flexibiliteit aan de vraagzijde te aggregeren (bundelen).

2. Efficiëntieverbetering vast te stellen als kernbeginsel voor systeembeheer in de distributienettarieven en niet-discriminerende toegangsbepalingen voor SES-infrastructuur.
3. Interacties mogelijk te maken op basis van data tussen systeemgebruikers onderling en tussen systeemgebruikers en systeembeheerders en een vangnet te bieden voor een betrouwbare elektriciteitsvoorziening.

Op basis van deze elementen voor een rechtskader voor SES worden in dit hoofdstuk de belemmeringen in het huidige rechtskader met betrekking tot systeembeheer, de toegangsvoorwaarden, de bescherming van de consument en de bevordering van duurzame energiebronnen in kaart gebracht. In dit hoofdstuk wordt ook het wetgevingsvoorstel van de Europese Commissie *"Clean Energy for All Europeans"* geanalyseerd tegen de achtergrond van de bevindingen van dit proefschrift, met name Richtlijn 2018/2001 betreffende de bevordering van hernieuwbare energiebronnen en de herziene richtlijn betreffende de elektriciteitsmarkt. Hoewel in het hoofdstuk wordt erkend dat de hervorming van de wetgeving over het algemeen de flexibiliteit van de vraag (*demand flexibility*) en de systeemgebruikers meer centraal stelt, wordt geconcludeerd dat de herziende richtlijnen de belemmeringen voor de ontwikkeling van SES die in het huidige rechtskader zijn vastgesteld, slechts ten dele wegnemen.

Uit de bevindingen blijkt dat een rechtskader dat SES aanmoedigt meer vereist dan het toevoegen van definities of het aanpassen van bepalingen in het huidige rechtskader voor de elektriciteitssector. Het proefschrift concludeert met de vaststelling van drie belangrijke beleidsimplicaties van een juridisch kader voor SES gericht op een verschuiving van gecategoriseerde systeemgebruikers naar flexibiliteitscapaciteiten, beheer van het elektriciteitssysteem dat zich niet beperkt tot kabels en meters, en data gebaseerde interacties. Elke implicatie heeft verstrekkende gevolgen voor de logica van het huidige rechtskader van de elektriciteitssector en zal verder moeten worden onderzocht.

CURRICULUM VITAE

Lea Diestelmeier was born 1988 in Germany. Her research expertise includes EU law in general and in particular EU energy law with a focus on the electricity sector and decentral solutions for the energy transition. Currently, she is a researcher at the Groningen Centre of Energy Law & Sustainability and is involved in a EU 'Interreg' project which investigates the implementation of cross-border local energy communities. Lea completed her Master's degree in European Law with a focus on Energy and Climate Law at the University in Groningen 2013. She obtained her Bachelor of Science in European Studies at the University of Twente and spent a semester at the faculty of Economics and Administrative Science at the Boğaziçi University in Istanbul. She is bilingual in German and Dutch.

A